Popular Astronomy.

Vol. XXIII, No. 6. JUNE-JULY, 1915. Whole No. 226

THE ASTEROIDS.*

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Because of the rapid progress in the discovery of asteroids, which has taken place within the last century, and because of the relationship which these little bodies seem to bear to Jupiter, the subject of the asteroids is well worth careful consideration.

A brief summary of the historical events connected with the first ones discovered is of interest and value.

At the beginning of the seventeenth century, Kepler noticed that the distances of the planets from the sun formed a regular progression, with the exception of the vacuity between the orbits of Mars and Jupiter. He made the daring statement that there was a planet in this space, its invisibility being due to its small size. Very little attention was paid to this idea of Kepler's until about 1772, when Johann Daniel Titius, a Professor of Wittenberg, pointed out the remarkable agreement between the distances of the planets, and the series of numbers 0, 3, $3x2$, $3x2^2$, $3x2^3$, etc., when each is increased by 4 and then divided by 10. He also pointed out the striking exception to the rule, which Kepler had noticed. This peculiar lack of a planet seemed still more strange when, in 1781, Herschel found Uranus in very nearly the place where it was predicted that the next planet beyond Jupiter should be according to the series of numbers. At this time, Johann Bode, who was just beginning his career in the astronomical world, was impressed by the remarkable way in which Uranus fulfilled predictions, and he published what is known as Bode's Law. Von Zach, a contemporary of Bode, felt so convinced of the existence of this undiscovered planet beyond Mars that he began to calculate its elements. He kept this idea in mind for fifteen years; then finally, in 1800, he succeeded in organizing a band of twenty-four astronomers for the purpose of making a systematic search for this planet. This band of astronomers met

* Part of a thesis presented to Carleton College in partial fulfilment of the requirements for the Master's degree, June 1915.

at Lilienthal, organized a society and divided the heavens into twenty-four zones. Their plan was to have each man observe one of these zones. However, they had scarcely begun observation, when news came to them that the object for which they were searching was discovered. Professor Guiseppe Piazzi, an Italian astronomer of Palermo, had been working on a star catalogue for nine years. On January 1, 1801, he found a star of the eighth magnitude in the constellation Taurus, which attracted his attention because of an error which Wollaston had made by assigning to Taurus a star which did not really exist. He repeated his observations the following night and found that the star had moved. This led him to believe that he had found a comet without a tail. He continued observing the object until he was convinced of its planetary character. In January he wrote to Oriani and Bode of his discovery, but the letter did not reach them until April 25. In February, Piazzi became dangerously ill and had to discontinue observation. The planet was now so near the sun that it could not be observed, and there was danger of its being lost entirely. At that time, astronomers had no means of determining an orbit from three observations, as is possible today. Piazzi's observations afforded insufficient data for the determination of the orbit by the methods then known. Gauss, then a young mathematician of Göttingen, surmounted this obstacle by discovering a new method of determining an orbit. By November, he had calculated the elements and ephemeris of the lost planet. For a time unfavorable weather prevented observation, but on the last night of the year, almost a year from the time of the original discovery, the little planet was rediscovered, very near the place where Gauss had calculated that it would be. The most interesting part of the discovery was that predictions based on Mathematics were confirmed by actual exploration of the skies. This completed the harmony of the system. At Piazzi's request, the planet was named Ceres, for the tutelary goddess of Sicily, the island where it was discovered.

On March 28, 1802, the remarkable order of Bode's Law was apparently overturned by the surprising news that Dr. William Olbers of Bremen had discovered still another planet. At first he thought it might be a variable star, but he soon came to the conclusion that it was a rapidly moving body. It appeared to be a very minute body, revolving about the sun at almost the same distance as the planet Ceres. This second planet, named Pallas, had an unusually large amount of deviation from the ecliptic and also large eccentricity. This led Olbers to conclude that there were still more of these bodies. He believed that these two planets were merely fragments of a large planet, which had been disrupted in some mysterious way many ages before.

He decided that the eccentricities and angles of inclination of these fragments might vary a great deal, yet their orbits would necessarily have two common points of intersection, at opposite points in the heavens. He proceeded to search the points of intersection of Ceres and Pallas every month. The discovery of a third planet, Juno, encouraged him to continue his search, and after three years his effort was rewarded by the discovery of a bright star in Virgo, which had not been there before. Gauss was given the opportunity of naming this planet, and he called it Vesta.

Considerable time elapsed before others were discovered. Hencke, who had been searching for new planets for fifteen years, found Astraea in 1845, and Hebe in 1847. Now the discovery of new planets has come to be a common thing. Since the year 1846, one or more planetoids have been discovered every year. Observers became very numerous, and great star maps were made, showing stars down to the thirteenth and fourteenth magnitudes.

These planetoids were called asteroids by Sir William Herschel, because of their small size and star-like appearance. Until over three hundred asteroids were discovered, most of them were named after mythological characters. Their number increased so rapidly that it became a matter of embarrassment to find a convenient method of designation. They are now numbered in order of discovery, the number being enclosed in a circle. They are also designated by the year of their discovery preceded by a combination of letters of the alphabet; for example number 780 was temporarily designated 1914 UC.

The asteroids are very small bodies, all being invisible to the naked eye except Vesta, which is only visible under very favorable conditions. The apparent diameter of the largest is less than one second of arc, therefore it is impossible to measure them accurately. Barnard measured the four largest with the great Lick telescope and found the diameters of Ceres, Pallas, Vesta and Juno to be 485, 304, 243 and 118 miles. The majority are much smaller and probably their diameters would not average more than 20 miles. It is impossible to determine their masses because their disturbing effect on other bodies is not appreciable. If their combined mass were $\frac{1}{100}$ that of the earth, they would cause perturbations in the orbit of Mars which do not exist. The conclusion is that the mass of the entire group is but a small fraction of the earth's mass. Many estimates have been made. Roszel calculated the total mass of those discovered to be less than $\frac{1}{3000}$ that of the earth.

Until 1891 the task of discovering a new planet was one of enormous labor and untiring perseverance. Numerous star charts were made and a portion of the sky, especially near the ecliptic, was compared

with these charts from time to time. If any strange object was seen, it was observed for several nights in order to ascertain whether it had moved since the preceding observations. In 1891 Wolf introduced another means of attacking the problem. He used photography with wonderful results. His method of procedure was to expose a plate for an hour or two. After being developed, the plate showed a round dot for each fixed star, and, if there happened to be a planet within range, an elongated dot would appear, indicating by the shape of the dot that the body had moved with respect to the fixed stars during the time of exposure. By this means, discovery became more rapid and as many as seven asteroids have been found on one plate.

Next, the orbits of these bodies in their various forms and positions may well be considered.

The orbit of a planet is determined by six elements: (1), a, the semi-major axis, or mean distance of the object from the sun, (2) P, the period, or the time in which a planet makes a revolution around the sun, (3) e, the eccentricity, (4) π, the longitude of the perihelion, (5) Ω, the distance from the vernal equinox to the ascending node, or the longitude of the ascending node, (6) i, the inclination, or the angle between the ecliptic and the plane of the orbit.

In Table I* are given these six elements for the eight hundred nine asteroids which have been discovered up to the year 1915. The data from which these elements were computed was obtained from "Bahnelemente und Oppositions-Ephemeriden der kleinen planeten für 1915," a supplement to the "Berliner Jahrbuch für 1917". "a" was obtained directly from "log a". "P" was calculated, using the formula,

$$P = \frac{2\pi}{\mu} \qquad \log (2\pi)'' = 6.11206$$

"μ" being given in "Bahnelemente." From "ϕ" in "Bahnelemente", $e = \sin \phi$ was calculated. "π" was obtained from the formula, $\pi = \omega + \Omega$, the "i" being neglected because in case of the majority of the asteroids "i" is small. "Ω" and "i" were taken directly from "Bahnelemente". Instead of being arranged in order of discovery as they are in "Bahnelemente", they are arranged in order of their mean distances from the sun, for the purpose of making it more convenient to study their distribution.

In Table I, the unit for column "a" is the mean distance of the earth from the sun, or about ninety three million miles. From this Table we find that the zone extends from 1.458 to 5.271, the difference of which gives as the width of the zone, 3.813 units. Therefore, the zone is nearly four times as wide as the mean distance of the earth from the sun. Of the eight hundred nine asteroids now known, Eros (433) is nearest and Hektor (624) is farthest from the sun. In this list, two

* Table I is so long that we are unable to give the space for it. [EDITORS.]

hundred fifty six asteroids have mean distances greater than three times the earth's mean distance. Of these, one has a mean distance of 4.3 and four others a little over five units. Their distribution seems to be very unequal, but a graph (Figure 1) shows a very decided maximum at the distance where according to Bode's Law a large planet should be. Figure 1 also shows certain gaps occurring at irregular intervals. Daniel Kirkwood, in his book entitled "The Asteroids, or Minor Planets between Mars and Jupiter", published in 1888, explains his theory of the distribution of the asteroids. He predicted that "those parts of the asteroid zone in which a simple relation of commensurability would obtain between the period of the minor planet and that of Jupiter are distinguished as gaps or chasms similar to the interval in Saturn's ring." In his study of the two hundred seventy one asteroids at that time discovered, he found this law to hold. It is interesting to see that, thirty years later, when eight hundred nine asteroids are known, all of them seem to be in perfect harmony with this law of distribution. Kirkwood says that those asteroids, the periods of which are commensurable with that of Jupiter, would be more and more disturbed by Jupiter's attractive influence and their eccentricities would become very marked. The influence of Jupiter is greatest at the time when this planet and the asteroid are in or near conjunction. Kirkwook states that "Jupiter's effectiveness in disturbing the motion of a minor planet depends on its order of commensurability." The more simple the relation of commensurability of the orbits of the asteroids with that of Jupiter, the more frequently would the conjunctions occur. For long periods of time, then, the perturbative effects of Jupiter on these asteroids would be cumulative, and their orbits would be more and more changed until they moved out of the range of Jupiter's influence. In that way, gaps or chasms would be formed in those particular parts of the

FIG. 1. DISTRIBUTION OF ASTEROIDS WITH RESPECT TO MEAN DISTANCES FROM SUN.

asteroidal zone. He expresses the ratios of Jupiter's period to the periods of the asteroids by fractions. The differences between the numerators and denominators of the fractions indicate the frequency of conjunction. The order of commensurability is also distinguished by this difference.

In general, the formula for the period of a planet is

$$P = \frac{2\pi a^{3/2}}{k\sqrt{1+m}},$$

k being the proportionality factor, and m the mass of the planet. If we denote the period, mean distance and mass of the asteroid by P_a, a and m_a respectively, and the period, mean distance and mass of Jupiter by P_j, j and m_j respectively, we have

$$P_a = \frac{2\pi a^{3/2}}{k\sqrt{1+m_a}}$$

$$P_j = \frac{2\pi j^{3/2}}{k\sqrt{1+m_j}}.$$

Their ratio, neglecting the masses m_a and m_j, would be

$$\frac{P_a}{P_j} = \frac{a^{3/2}}{j^{3/2}}.$$

First, taking the simple ratio ½,

$$\frac{1}{2} = \frac{a^{3/2}}{j^{3/2}} = \frac{a^{3/2}}{(5.2)^{3/2}},$$

$$a = \frac{5.2}{2^{2/3}} = 3.277.$$

In the same way we may take the ratio ⅓ :

$$\frac{1}{3} = \frac{a^{3/2}}{(5.2)^{3/2}}$$

$$a = 2.50.$$

By proceeding in this manner, we may find "a" for any of the simple ratios. The following table shows the results obtained.

TABLE II.

First Order		Second Order		Third Order		Fourth Order		Fifth Order	
Ratio	Distance	Ratio	Distance	Ratio	Distance	Ratio	Distance	Ratio	Distance
1/2	3.28	1/3	2.50	1/4	2.06	1/5	1.78	1/6	1.57
2/3	3.97	3/5	3.70	2/5	2.82	3/7	2.95	2/7	2.26
3/4	4.29	5/7	4.15	4/7	3.58	5/9	3.51	3/8	2.70
4/5	4.48	7/9	4.40	5/8	3.80	7/11	3.85	4/9	3.03
5/6	4.60	9/11	4.55	7/10	4.10				

In Figure 1, we find a decided gap at the distance 3.277, corresponding to the ratio ½. This gap extends from 3.246 to 3.328, giving for its breadth .082, or .021 of the entire zone. All other ratios of the first order give distances outside the limits of the region where asteroids are found in any number. For the second order, gaps are noticeable at the distances 2.50 and 3.70. For the third order, we find gaps at the distances 2.82, 3.58, and 3.80. In examining the ratios of the fifth order, we find that 2.26 and 2.70 correspond to less pronounced depressions in the curve, indicating that Jupiter's influence is less as the order of commensurability becomes large. This is in perfect agreement with what we should expect to find at this point. The increase in the number of asteroids now known only serves to emphasize the thought that these gaps are not accidental, and to strengthen the probability that they are caused by the disturbing influence of Jupiter.

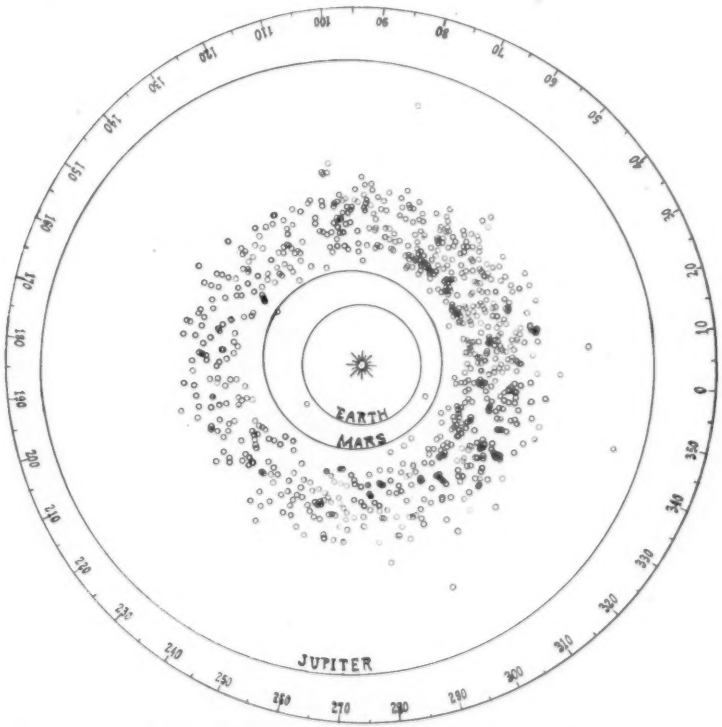


FIG. 2. DISTRIBUTION OF PERIHELIA OF THE ASTEROIDS.

Figures 2 and 3 show the distribution of the perihelia and aphelia, respectively, of the eight hundred nine asteroids, taking into consideration both the longitudes and the distances of the perihelia and aphelia. From Figure 2 it can readily be seen that there are three

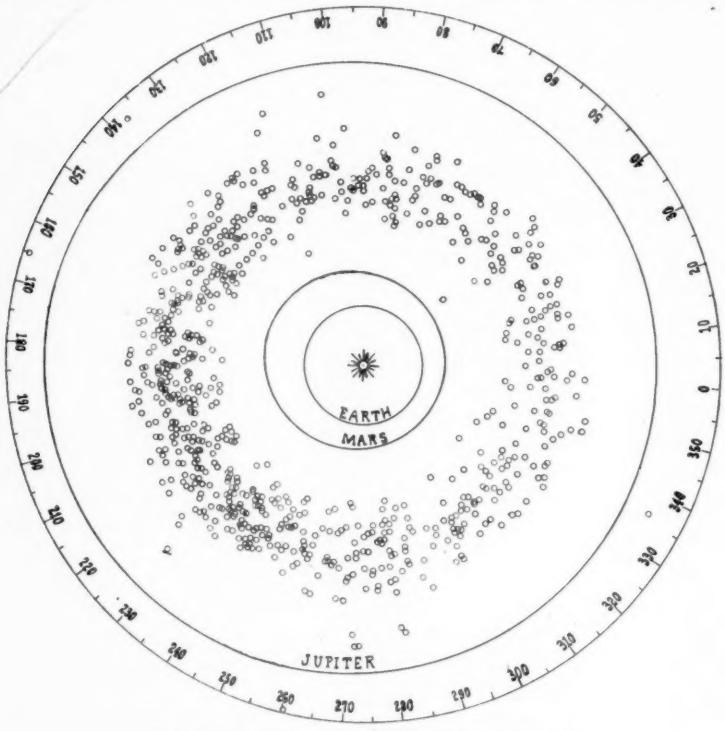


FIG. 3. DISTRIBUTION OF APHELIA OF THE ASTEROIDS.

asteroids which have their perihelia within the orbit of Mars. These three are Eros (433), Albert (719), and Phocaea (25). In Figure 3 we find four whose aphelion points are outside the orbit of Jupiter, viz., Hektor (624), Nestor (659), Patroclus (617) and Achilles (588). Achilles ventures out to a distance six times as far as the earth is from the sun. These four asteroids are among the more recent discoveries and are known as the Trojan group.

Figures 2 and 3 show very clearly a marked condensation in both the perihelia and aphelia. As would naturally be expected, these condensed portions are 180° apart. The majority of the perihelia are included between longitudes 320° and 70°, while the most of the

aphelia are found to be between 130° and 250°. In this respect, the asteroids exhibit a striking resemblance to Jupiter's family of comets. Nearly all the farthest points of the orbits of this family of comets are on one side of Jupiter's orbit, as pointed out in the articles by William W. Payne, published in "POPULAR ASTRONOMY," first in Volume I, pages 25 and 62, later in Volume XIV, page 221. Their perihelia and aphelia are within the same limits in longitude as those of the asteroids, as shown in Figure 2. It was suggested by Professor Payne that, since the whole solar system is drifting in space in the direction towards a point in the constellation Hercules having right ascension 267° at the rate of twelve miles per second, Jupiter's velocity on one side of his orbit would be about five times as great as on the other side, and for that reason Jupiter would probably meet or overtake more comets at the former rate than at the latter. The question now arises whether attractive force of Jupiter has affected the orbits of the asteroids in the same way, as Figure 2 would seem to indicate. In case it does, what light does that give concerning the possible origin of the asteroids? Does it indicate a special relationship between the asteroids and the periodic comets, which have been gathered within the orbit of Jupiter by the action of that planet? Is this another practical demonstration of tendencies in the universe which would strengthen our belief in the Capture Theory?

The inclinations of the asteroids, as given in Table I, vary from 0° to 35°. The smallest inclination, that of Chrysothemis (637), is 0° 20′; the largest, that of Pallas (2), 34° 42′. The angles of inclination are distributed as follows:

TABLE III. DISTRIBUTION OF INCLINATIONS.

	Inclination	Number
From	0° to 4°	151 asteroids
	4 to 8	221
	8 to 12	198
	12 to 16	135
	16 to 20	57
	20 to 24	26
	24 to 28	16
	28 to 32	2
Above	32°	3

Figure 4 illustrates this point and shows a maximum between 4° and 8°.

Figure 5 shows that the eccentricities also vary widely. The least eccentric of the group is Edda (673), the eccentricity of which is .0109. The most eccentric is Albert (719), with the eccentricity .5406. Table IV shows the distribution of the eccentricities.

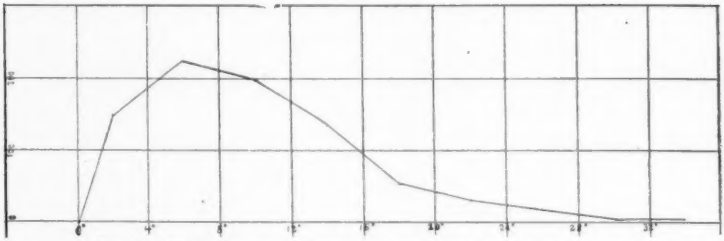


FIG. 4. DISTRIBUTION OF ASTEROIDS WITH RESPECT TO INCLINATION.

TABLE IV. DISTRIBUTION OF ECCENTRICITIES.

Eccentricity	Number	Eccentricity	Number
.01 to .03	22 asteroids	.23 to .25	52 asteroids
.03 .05	48	.25 .27	24
.05 .07	63	.27 .29	11
.07 .09	66	.29 .31	11
.09 .11	78	.31 .33	6
.11 .13	89	.33 .35	8
.13 .15	73	.35 .37	1
.15 .17	80	.37 .39	2
.17 .19	71	.41 .42	2
.19 .21	53	.44 .46	1
.21 to .23	47	.54 to	1

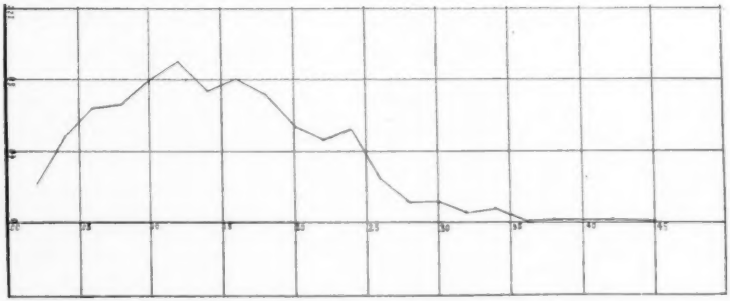


FIG. 5. DISTRIBUTION OF ASTEROIDS WITH RESPECT TO ECCENTRICITY.

The periods of the asteroids were computed by using the formula $P = \frac{2\pi}{\mu}$, so from the nature of μ the periods depend on the mean distances. Therefore, we would expect to find the same irregularities in the periods that we found in studying their mean distances. The periods are given in days. Table V shows two well-defined maxima—from 1500 to 1700 days and from 2000 to 2100 days.

TABLE V. DISTRIBUTION OF PERIODS.

Period	Number	Period	Number
Less than 1100 days	2 asteroids	2000 to 2100	131 asteroids.
1100 to 1200	23	2100 2200	9
1200 1300	42	2200 2300	13
1300 1400	79	2300 2400	12
1400 1500	47	2400 2500	1
1500 1600	113	2500 2600	1
1600 1700	128	2800 2900	6
1700 1800	67	3200 3300	1
1800 1900	52	4300 4400	3
1900 to 2000	78	4400 to 4500	1

The decided fall from 131 asteroids to 9 asteroids after the interval 2100 to 2200 days corresponds to the gap at the distance 3.277 in the case of the first order of commensurability. A similar correspondence may be found for the other gaps.

In making a study of the column in Table I containing the longitudes of the ascending nodes, we find a great amount of irregularity.

TABLE VI. DISTRIBUTION OF ASCENDING NODES.

Ascending Node	Number	Ascending Node	Number
From 0° to 10°	34 asteroids	180° to 190°	30 asteroids
10 20	16	190 200	12
20 30	21	200 210	29
30 40	32	210 220	23
40 50	33	220 230	13
50 60	9	230 240	21
60 70	26	240 250	14
70 80	22	250 260	17
80 90	30	260 270	17
90 100	27	270 280	10
100 110	27	280 290	19
110 120	11	290 300	22
120 130	26	300 310	18
130 140	30	310 320	16
140 150	31	320 330	19
150 160	22	330 340	24
160 170	20	340 350	23
170 to 180	33	350 to 360	32

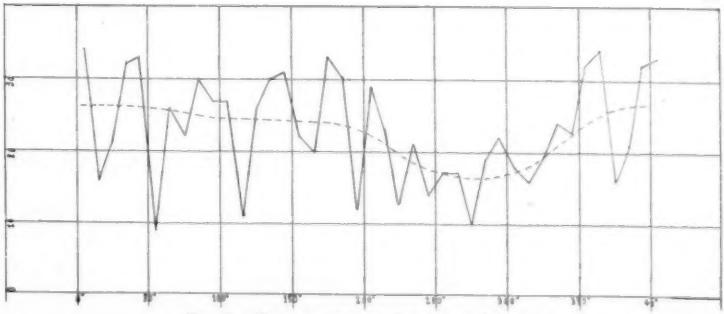


FIG. 6. DISTRIBUTION OF ASCENDING NODES.

Kirkwood speaks of two well-marked maxima, each extending about sixty degrees, from 310° to 10°, and from 120° to 180°. He mentions the non-coincidence of either of these maxima with the arc from 46° to 130°, which contains the ascending nodes of all the large planets. With the data concerning eight hundred nine asteroids at hand, we find in Table VI that the two maxima he mentions are no more marked than several others. In general, the one hemisphere from 0° to 180° might be considered as a maximum and from 180° to 360° a minimum. Otherwise, as is shown in Figure 6, the graph is extremely irregular.

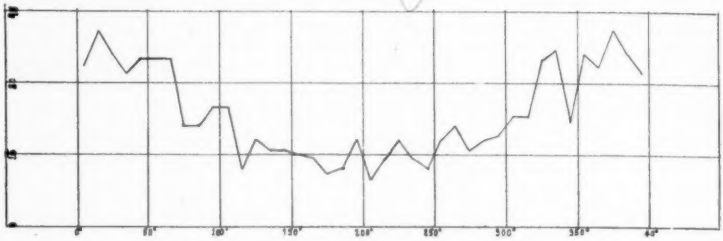


FIG. 7. DISTRIBUTION OF LONGITUDES OF PERIHELIA.

Figure 7 and Table VII show the distribution of the longitudes of the perihelia in a similar manner.

TABLE VII. DISTRIBUTION OF PERIHELIA.

	π	Number	π	Number
From	0° to 10°	34 perihelia	180° to 190°	12 perihelia
	10 20	41	190 200	18
	20 30	36	200 210	10
	30 40	32	210 220	14
	40 50	35	220 230	18
	50 60	35	230 240	14
	60 70	35	240 250	12
	70 80	21	250 260	18
	80 90	21	260 270	21
	90 100	25	270 280	16
	100 110	25	280 290	18
	110 120	12	290 300	19
	120 130	18	300 310	23
	130 140	16	310 320	23
	140 160	16	320 330	35
	150 160	15	330 340	37
	160 170	14	340 350	22
	170 to 180	11	350 to 360	36

This shows a maximum between 320° and 70° and a minimum between 130° and 250°. These are shown in another way in Figure 2.

A VISIT TO THE MT. WILSON OBSERVATORY AT PASADENA.

S. C. HUNTER.

A very superficial knowledge of a subject will sometimes lead to unexpected enjoyment. Perhaps I have never realized this more keenly than during a recent visit to Pasadena and a call made while there at the Mt. Wilson Observatory.

By very good fortune I had the rare pleasure of enjoying a forty minutes talk with Professor G. W. Ritchey, who is in charge. It seemed almost inexcusable to claim so much of his valuable attention, but one thing led to another until the point of time was entirely forgotten.

The attraction at this place is the far-famed great mirror being slowly ground for the reflector to be set up on Mt. Wilson, which when completed will probably reveal as much of the unexplored heavens, compared with our present knowledge, as did the original glasses of Galileo, compared with the knowledge which preceded them.

It was not the regular visitors' day, but I explained to the attendant that I had come a long way, and was interested in astronomy perhaps more than the ordinary visitor by reason of my connection with the Variable Star Association, &c. This identification apparently entirely sufficed, as I was passed on without further parley to Professor Ritchey, who was most cordial and courteous. The huge mirror (which by the way is precisely 101 inches in diameter and not 100, nor 105 as I have seen it variously stated) was resting in an upright position supported by the various devices used in handling it. It occupied a protected room which opened into a connecting hallway also protected as well as possible from dust by padding on the door edges. The hallway was of sufficient length to provide the distance necessary for setting up the testing appliances which were used in figuring the surface. This figuring or proving process takes place each morning before the surrounding air has suffered disturbance from the over-night settling. It is difficult to realize the task of securing the perfection of convexity that is necessary. The great size of the glass vastly increases the obstacles. It is sufficient to say that four years have been spent on the work thus far and still another year will be required to finish it. There it stands like a great jewel, to the untrained eye perfect in form and polish, and yet still susceptible to corrective measurements which require the use of delicate instruments in expert hands.

We were passing Professor Ritchey's office door when he suggested that I look in at some of the photographic plates which were arranged along the walls. Little did I imagine what was to be revealed. Here were photographs of various nebulæ which stand for the last word on

the subject that exists in the world today. The photos were taken at the Mt. Wilson and Yerkes Observatories by Professor Ritchey with the 60-inch reflector at the former and a two foot reflector at the latter place. As these are the greatest instruments of their kind and as Professor Ritchey is perhaps the most expert of celestial photographers, the minute and startling detail and unexpected magnificence of the objects portrayed can scarcely be imparted by any kind of verbal description. It is safe to say that never since the invention of the telescope has the human eye penetrated so far into the mystery and complexity of nebulous construction as shown by these plates, several of which were the originals of the printed copies that I understand appeared for the first time in Abbot's "The Sun", published in 1911; but the original plates, being so much larger and clearer of definition than the printed copies, afford a wealth of detail quite difficult to describe. For instance, the core of the Andromeda Nebula cannot be properly conveyed to the eye by a printed copy; but the original plate brings this out as a huge body or mass of great brilliancy, clearly separated from the surrounding matter. One is lost in speculating as to what it means. The major lights in the Pleiades and the spear points or shafts of light emanating from them and piercing the nebulous haze differ in character and geometrical form as if each star had a personality of its own similar to the diversity found in individuals. The wonderful plate of the Spiral Nebula M 51, taken with the Mt. Wilson 60-inch reflector, was a subject one might study for an hour. No printed picture could begin to convey the glories of the original plate; and so with the Ring Nebula in Lyra with its curious basket weaving effect and shaded ends.

Nebula N.G.C. 6992 Cygni, although taken with the two foot reflector at Yerkes Observatory, a smaller instrument than the one on Mt. Wilson, was a beautiful object and looked as if it were some delicate piece of fabric made of the finest lace suspended among the stars.

There were two plates of Messier 15, one showing the usual grouping of the stars with the blurred central mass, and the other a carefully timed exposure of this central mass alone, which broke it up into its constituent star points and a background of shadowy stars still further beyond, or of lesser magnitude. Many other interesting plates were discussed, some of which I understood had not been reproduced yet in any work.

There would seem to be no doubt about the advantages of the California atmosphere for celestial observation. For instance, with the sun dazzlingly bright in a cloudless sky, the rising March moon, just before the first quarter, was visible all day in full detail, its position being from 40 to 45 degrees behind the sun. I also understood that the bright stars are easily discernible in the Sierras on any clear day by looking overhead between the tall pine trees.

THE SPELL OF THE SOUTHERN STARS.

ADA WILSON TROWBRIDGE.

[*Continued from page 284.*]

ARGO AND CANOPUS.

"Amidst them, next,
A light of so clear amplitude emerged,
That winter's month were but a single day
Were such a crystal in the Cancer's sign!"

DANTE.

South and west of Sirius, seven second magnitude stars and the resplendent Canopus mark where the good ship Argo pushes her course through the Milky Way. For over twenty-eight centuries this vessel has sailed the heavens freighted with the imagination of millions of watchers, and stored with countless beautiful traditions, since that glad day when the first craft, as Dante's measures have it, "startled Neptune with the aid of Argo." Thus, it has been said that the constellation was formed to represent the first ship that sailed the ocean. It has also been called the ship of Jason, and has figured as the ark in the Egyptian, Hindu, and Hebrew legends of the flood. Although most of the ancients saw a ship in the outlines of Argo, we of today, little prone to bodying familiar shapes, see more the wandering points of bright stars, crossing and recrossing the Milky Way. Even to our less imaginative eyes, the hero springs from the stalwart shoulders of Orion, or the bold archer from the drawn bow of Sagittarius, or the stringed instrument from the musical swing of Lyra. With the stars of Argo, scattered over nearly 75 degrees in length, there is, perhaps less of the ship of the sea; but more, albeit, of the wonder which surrounds revelations of modern science.

Argo stretches over more degrees of space than any constellation in the heavens, and contains eight hundred and twenty seven naked-eye stars. It lies entirely in the southern hemisphere, and Sir Isaac Newton fixed the date of its configuration at about 936 B.C., or not far from the time of King Solomon. But a small portion of Argo is visible from northern latitudes; the bright second magnitude star, Zeta, lying in the Milky Way about 25 degrees south and east of Sirius, and several inconspicuous stars of the northernmost part of Argo, however, can be seen at the latitude of New York. The entire constellation is visible from Key West, although Beta, at the extreme southern point of the keel, is above the horizon for only a short time; the wonderful Canopus,

and the brightest stars, with the exception of Beta, are visible from all other parts of Florida. Gamma Argus, of the second magnitude, lies in the Milky Way, about 10 degrees south of Zeta, and is of great interest to the astronomer as it is the only bright star showing a certain type of continuous spectrum crossed with bright lines. R. H. Allen says, "Its superb beauty is the admiration of the spectroscopic observer," and he states that it has been called the "spectral gem of the southern skies." Passing southward about 10 degrees from Gamma and slipping along the Milky Way for nearly 40 degrees, the eye meets one of the most interesting parts of the Galaxy, and the most extraordinary variable star in the heavens. This variable, Eta, in 1843 was said to be as bright as Sirius; in 1876 it was barely visible; and now it is again increasing in brightness, being somewhat brighter than a fifth magnitude star. Old Chinese records, and legends almost pre-historic, appear to bear reference to the noticeable variation in the brightness of this star, thus indicating that it has always been one of the notable objects in the heavens. It is a reddish star, and is usually known as the Eta Carinae nebula, one of the densest and most splendid in appearance, and one that is associated with a remarkable portion of the Milky Way. It is in the region of the Southern Cross, and can be seen in the southern part of Florida, although it is difficult to locate without the aid of a glass, as the star is faint and merges into the general nebulous appearance of the Milky Way.

Canopus, the wonder of the constellation of Argo, can be located by any observer without difficulty, as it so plainly outshines all the stars in the heavens with the exception of great Sirius. It lies about 36 degrees south of Sirius and a little to the west, and thus the stars are seen together, making it possible for one to compare their aspects in their splendid journey across the heavens. Canopus is invisible north of the 37th parallel, although at that latitude it can be seen for a short time just above the horizon at nine o'clock about the sixth of February. Without question Canopus appears the great star-god of the firmament. Although no brighter than Sirius, it blazes, flashes, and coruscates until it seems to magnetize that part of the heavens. There is something serene and planet-like about Sirius, but Canopus is fitful and supernatural as if reflecting the moods of some great spirit. Perhaps the knowledge of its commanding size adds power to the influence which this star holds over the imagination. At all events, this most magnificent sun of the visible universe flashes its mysterious power down to us through a space too vast to be measured.

It requires definite keenness of the mind and conscious exercise of the imagination to grasp conceptions so vast as those which have been called forth by computation of the distance, size, and heat of Canopus.

Only those who are accustomed to thinking in sidereal distances and picturing the real as well as the apparent physical relations of the heavenly objects can readily grasp astronomical phenomena. Dr. Elkin's experiments for ascertaining the distance of Canopus oblige one to suppose that it takes sixty-five years, at the very least, for its light to reach us. Taking this minimum remoteness, our sun at the same distance would appear to us only as a seventh magnitude star, invisible except by the aid of the telescope. Computations show that Canopus must be brighter than the aggregate light of twenty-five hundred suns like ours, and is probably vastly brighter than this conservative estimate. Professor Simon Newcomb estimates that Canopus is ten thousand times larger and ten thousand times hotter than our sun, and states that the sun and family of planets would vaporize should they approach within ninety million miles from Canopus. Indeed, so stupendous is the size and heat of this orb that the theory was advanced by astronomers in times past that Canopus is the Great Central Sun around which all other suns and solar systems are revolving.

From prehistoric times Canopus has been observed and regarded as an object of superstition and worship. In Egypt it was worshipped, as the orientation of many temples testifies, and to-day it is an object of worship with the Budawiyy tribes and other tribes of the central and southern Sahara. There are many traditions as to the origin of the name Canopus, the oldest, and perhaps the most authentic, being that the origin is Coptic and means "golden earth." Many names in different languages can be traced to the Coptic symbol and meaning, and almost all names, from whatever source, bear reference to the glory and brilliancy of the star. Indeed, Allen makes the statement that to-day, among the nomads of Arabia, the same word used for the star Canopus is applied also to handsome or distinguished persons. On the famous Karnak tablet, engraved at the time of Thotmes III to celebrate his victories, is the oldest historic poem known to science. In this ancient epic, written near 1600 B. C., are lines referring to the appearance of Canopus at sunrise at the time of the autumnal equinox. And many centuries later we find Canopus figuring with the Three Graces of Dante,—Canopus, Achernar, and Fomalhaut,—

> "Those torches three
> With which this hither Pole is all on fire."

Canopus is a white star, and distinctly diamond-like in its deep, gleaming intensity; and at times it flashes with such darts of red, green, orange, and blue, and glows with such spirit-like fire, it seems, among all the hosts of heaven, the one great, conscious symbol of divinity and power. During November and December it may be seen

between midnight and dawn, sometimes burning and restless, and sometimes bearing a message of infinite harmony and repose. In January and February it is visible in the earlier evening hours, and as twilight puts out the flame from banks of blossoming poinsettias, an answering gleam of red comes from Canopus between the silhouettes of palm-fans. As Alpha and Beta Centauri suggest the late blossoming of orange and grapefruit groves, so is Canopus associated with the golden, ripened fruit. It is the star that reflects the brilliant hues of tropical gardens,—the red of the hibiscus, the burnt orange of the bignonia, the purple of the bougainvillea,—and sums all the wealth of the tropic night, when the mocking birds sing for ecstasy from twilight to dawn.

ARA, GRUS, PHOENIX, AND PICTOR.

"The virtue and motion of the sacred orbs,
As mallet by the workman's hands, must needs
By blessed movers be inspired."

DANTE.

So far as legendary interest is concerned, the Southern Hemisphere, with the exception of the notable constellations and stars just described, does not contain many striking asterisms south of parallel 40. The groupings, for the most part, are modern, and the sky is studded with many trifling constellations representing the incongruous results of inferior or jaded imaginations. The compelling touch of poetry is not there as in the wonderful pagentry of fancy that circles the north Pole. The stars themselves, however, the brightness and remarkable character of the Milky Way, and the dark spaces of immensity but dimly lighted by distant suns, awaken a feeling of solitariness and awe, as if the beholder were, indeed, searching the very limits of the universe.

South of the tail of the Scorpion is a little group of stars that burn faintly, like sparks driven from some brighter flame. This is Ara, or the Altar, an ancient constellation that for some reason strongly figures to the imagination the spirit of the name, without suggesting clearly the outline of an altar. Alpha, Beta, and Gamma, its brightest stars, are all of the third magnitude, and the remaining ones are yet fainter. Although the stars are not brilliant, they make an appeal to the fancy, and the present grouping was made at an early date, Ara having been known among the fifteen ancient southern constellations. Aratos pays a poetic tribute to it in his astronomical epic, and here and there it appears in legend and story, even to the seventeenth century when zealous churchmen, eager to write the symbols of their ceremonials on the heavens, attempted to change the name from Ara to "the Altar of Incense." In this prosaic Christian invasion, let me say in passing, Canis Major was to become the Dog of Tobias; Canis Minor, the Paschal

Lamb; Orion, St. Joseph; Virgo, St. James; Ursa Major, St. Peter's Fishing Boat; Sagittarius, St. Matthew; and thus through the entire cycle of classic imagery. Let us be thankful that the warmth of innate poetry in the race was too strong for the chill blast of Christian zeal, and that we have had preserved to us the picturesque and romantic lore of paganism. Ara lies in the Milky Way south of parallel 50, and is not visible in the north. Beta Arae is a red star, and Alpha and the other brightest ones are yellowish.

Perhaps the two bright stars, Alpha in Phoenix and Alpha in Grus, appear more beautiful because of their proximity to Fomalhaut. They are south of Fomalhaut, the one to the east, the other to the west, and the three make a triangle which marks a dark and solitary part of the heavens apparently unbroken by sidereal lamps save here and there where the faint flicker of some dim star comes and goes. Fomalhaut is the lonely star of rustling autumn evenings, in the north; and in the south, also, it suggests the ruddy, fruitful autumn, and conveys to the emotions the same atmosphere of serenity and solitude. The two yellow second magnitude stars in Phoenix and Grus are not near enough to Fomalhaut for companionship, and the three stars, strangely bright in the clear southern night, are like splendid guiding lights in some dark, unknown sea.

West of Canopus, and about 45 degrees almost directly south of Rigel, lies a faint group of twenty third to fifth magnitude stars known as Pictor, a constellation of great interest and importance because it contains that fascinating object called by astronomers the "Galloping Star." This is an orange-colored, eighth magnitude, telescopic star having the fastest proper motion yet observed in the universe. The motion is 8″.7 annually or about nineteen million miles a day.

In the northern hemisphere, in Ursa Major, is situated 1830 Groombridge, the star with the second greatest proper motion, its velocity being 7″.03 annually, or seventeen million miles a day. So staggering was the thought of this tremendous speed, it was felt at first by some astronomers that the star must be a visitor from another universe; and Professor Newcomb has said that the combined power of attraction of the entire sidereal universe could not control such a speed as that of 1830 Groombridge.

So, although this wonderful Galloping Star in Pictor is not visible to the naked eye, one will watch for the distinguished little constellation as it comes to the meridian about eight o'clock in the evening the first of February. Pictor is one of the notable features of the mid-winter sky for all those who are eager not only to observe every detail of the stellar display which each month rolls before the view, but also to catch all those points of mystery and wonder which the imagination may build upon.

THE MILKY WAY.

"Thus leads the Galaxy, from pole to pole,
Distinguished into greater lights and less,
Its pathway, which the wisest fail to spell."

DANTE.

At last, with the introduction of photography into astronomy, the entire extent of the Milky Way is being charted with accuracy. Professor Solon I. Bailey speaks of the Milky Way as "the central feature in the structure of the stellar system," its plane being "that of ultimate reference in any study of the distribution of the stars;" and Miss Clerke writes, "All the contents of the firmament are arranged with reference to it." The Galaxy as it appears to the naked eye has been faithfully drawn in detail by observers through many centuries, but this manner of depicting the intricate structure can not be sufficiently accurate to prove altogether satisfactory. It was not until the year 1909 that an attempt was made to photograph the Milky Way systematically throughout its entire length.

This valuable work was done by Professor Bailey and Mr. Shultz, the station for photographing the southern portion being at Hanover, Cape Colony, in the Great Karroo plateau of South Africa. The results of this undertaking have been published and include a series of magnificent photographs covering the entire Milky Way from the region of Sirius across the hemisphere to the constellations of Ophiuchus and Aquila. Nothing thus far portrayed by the camera can compare to the revelations of these amazing photographs. One can not describe, and one can not comprehend without deep contemplation, the wonder and the awe of the limitless wilderness of suns, the dense knots of light as if systems had been hurled one upon another, and the vast extent and remoteness of this sublime zone of light. Reason and imagination are alike confounded.

A good field or marine glass or a small telescope is necessary if one would enjoy in full measure the beauty of the Milky Way. Garrett Serviss writes, "Anyone can easily trace the meanderings and branchings of this starry scarf, the contemplation of which carries the mind to greater heights of intellectual perspective than any other phenomenon of the world of matter;" and even for those whose enthusiasm and deeper response has not yet been touched by the stars, a little effort in tracing the southern wanderings of the Milky Way will reveal undreamed of beauty and mystery.

In many respects, both to the naked eye and through the telescope, this southern portion is the most striking and interesting, containing as it does so many noble star clusters, dark lanes and rifts, the Coal Sack, nebulous masses, swirls and fissures that appear to mark the

encounter of great forces, and luminous nodes and waves such as are seen especially in the region of the Southern Cross and some portions of Sagittarius and Scorpio, where the stars seem to be wading in light.

Below Sirius, the Milky Way begins to pale and narrow somewhat, and to display an even and unbroken sheen of light. Passing into Argo, it widens once more, and between Gamma and Lambda Argus is separated into rifts showing lines and patches of dark and light. Toward the Southern Cross it increases in brightness and shows nebulous knots of light, the most conspicuous being the Eta Carinæ nebula of Argo already described. The part surrounding the Southern Cross and Alpha and Beta Centauri is surpassingly beautiful, being especially bright, and marked by a dark rift east and south of Alpha and Beta Centauri, and the black irregular gap east of Alpha Crucis called by sailors the Coal Sack. Near the constellation Ara the light is faint and increases in brightness and granular appearance in Scorpio and in the other branch that swings into Sagittarius. For brightness and extent, for many and dense globular clusters, and for the intricate rifts, this region is in many respects the most remarkable in the sky.

After viewing the Milky Way almost from pole to pole, as one may in a trip from the northern states to southern Florida, one is aware of the influence which must needs be exerted upon the mind of man by this gossamer zone of light swung around the heavens, as if in final challenge to one's most spiritual sense of the beautiful. And it will prove the last stronghold of fancy, one may well believe, in the steady conquest of science.

THE STAR-LIGHTED FIRMAMENT.

CHARLES NEVERS HOLMES.

When day is done, when its turmoil and troubles are over, when most men are home from their business, and the sunset has faded into twilight, and twilight into the dusk of evening, when dinner has been eaten and the newspaper has been read, the time comes when one may leave his house and take a walk out of doors. As he closes the door of his home, the cool, fresh air invigorates him, and he starts out briskly, soon reaching the outskirts of his particular suburb, where with the exception of an occasional speeding automobile all is quiet. But the electric lights are still shining upon his roadway, reminding him too much of the glitter and artificiality of the city, and he soon leaves the road, entering some grassy field where everything is dark and silent. It is a level field, the walking is good, and without being aware of it he has covered quite a distance. Suddenly he pauses, and,

as it were, awakens from a dream, for while he has been walking his thoughts have been far away. He pauses somewhat startled. He is lost! He is in utter darkness, utter silence, some distance from home. He is all by himself, there is no one to disturb him.

Then he hears a brook purling close by; but that is the only sound anywhere around him. Slowly he raises his head, at first all seems dark above as below. Then, as though some veil had been drawn aside, the stars of the bespangled firmament suddenly sparkle and scintillate upon him. He is no longer lost, he is no longer in utter darkness. He is no longer friendless and alone. He is still all by himself, but in the presence of grandeur compared with which the grandest palace is a hovel and even the most magnificent landscape a mean, insignificant spectacle.

The great Dipper of Ursa Major hangs white and conspicuous in the star-lit sky. Constant as ever, Merak and Dubhe point fixedly in the direction of Polaris, which twinkles rather unnoticeably in the north. Not far away there wind the stars of Draco, his terrible jaws gleaming over at Hercules. Also not far away there lies the inconspicuous constellation of Cepheus; the well-defined outline of Cassiopeiae sparkling close by, while to the northwestward brilliant Capella still blazes like a starry beacon over the sunken glories of winter's glorious galaxy. Slowly Regulus and his Sickle are drifting towards the west, with bright Spica in Virgo at some distance behind him. In the southeast there glows the ruddy, weird fire of Antares, below the tail of the serpent and the lower stars of Ophiuchus. Above Serpens and Ophiuchus there glimmers dim Hercules, and there gleam once more the jaws of Draco, cruel and relentless.

Arcturus!—grand Arcturus! Gleaming and glittering like a titanic sky diamond. Harbinger of springtime, monarch of summer's suns of night. Arcturus of Boötes, almost comparable in brilliance with incomparable King Sirius. And Vega!—blue, beautiful Vega! Sparkling and scintillating more royally than Arcturus. Queen of summer's suns of night, great rival of Arcturus yet different from him in firmamental appearance. Vega of Lyra, which shines in August as a zenith-sun, and lingers as though reluctant to leave her throne until brilliant Capella rising out of the northeast warns her that she must go.

The Northern Cross—the Crux of Cygnus! Following blue Vega and seeming in some way to belong to that most beautiful sun. The Northern Cross! A true starry Cross, whose five suns glitter in a large, symmetrical outline. A firmamental Crux that lies upon and across the background of the Milky Way, with Altair Aquilae rising in belated splendor to the eastward! The Northern Cross and—the Northern Crown, Corona with its brightest jewel Alphecca!

Lost indeed in thought and admiration, although perchance startled by the sudden, fiery death of some shooting star, man stands in lonely silence amid that grassy field, gazing as though beyond these nearer stars into a depth unpenetrated by the most powerful eye of telescope. Beyond satellite and planet, beyond Vega and Arcturus, beyond a hundred light-years and the Milky Way, the mind of man flashes in a moment, soaring into vast reaches of space where it may be that never a sun will blaze or a planet revolve. But the mind of man is finite and it cannot explore into the infinite. Soon, wearied of such a stupendous excursion, man's thought returns earthward, and he pauses once more to study and admire the splendors of the star-lighted firmament.

And what a firmament it is! Jewels of fire set in a frame of ebony! Blazing beacons journeying hither and thither. Myriads of solar systems like sidereal families held together by a powerful, invisible law. Solitary suns, and suns that travel in company. Titanic sky-furnaces, and tiny, dying solar bodies. Spectral comets and glowing nebulae. And what an incalculable number of derelicts! Aerolites, small, large and vast. And "dead suns"—do they or do they not exist? If they do exist, what are their numbers? It is possible, is it probable, that in some future age such a dead sun like a terrible devastating shell shall come tearing through our own solar system, shattering it asunder, and perhaps leaving our earth in fragments or hurled out of its present orbit of solar revolution?

But the thought of man must finally return to earth. His eyes leave the star-lighted firmament and its stupendous problems, and he finds himself amid the loneliness, silence and darkness of a grassy field. Then as he hesitates, hardly knowing in which direction to go that he may once more reach his home and its society, he hears some distant church clock intoning the hour of ten. He begins to walk away from the purling music of the brook and after a time, by good fortune, comes upon the roadway where the electric lights still shine, reminding one of the glitter and artificiality of the city. Once more he turns to take a farewell look at the star-lighted firmament, and then he perceives that from behind a wooded knoll the full moon is rising, and he watches for a while until the darkness and desolation of the landscape disappear before the silvery radiance of the queen of night. Reluctantly he leaves the grassy field and takes the roadway back towards the garish lights of the city. But he is richer, more spiritual, than when he left his home. The world seems a better place in which to dwell, and he re-enters his house conscious of having witnessed a spectacle that is the greatest and grandest to be viewed on the surface of man's tiny planet home.

Hotel Nottingham, Boston, Mass.

THE MOON.
ORIGIN, TIDES, CRUST, MOUNTAINS.

MARIAN McFADDEN AND IRENE WINGARD.

Have you ever wondered as you looked at the moon in the sky, how it came to be there? The people, as a whole, are willing to receive the fact that the moon is in the sky and leave to the astronomers the long and difficult task of finding out, by hard study and work, the origin of the moon. Several astronomers have advanced theories. One astronomer suggests that the moon was pulled bodily out of the earth and the space now occupied by the Pacific Ocean was formerly occupied by the moon. This strain broke the thin crust on the side of the earth opposite the Pacific Ocean. These fragments floated from each other on their liquid keel, and when they became solid enough to remain stable, they had formed the eastern and western continents and Australia. In proof of which, one may take a map of the world; he will find that England will fit into the Gulf of St. Lawrence, South America into the Gulf of Guinea, and Australia, pushed up, will fit into the Indian Ocean. In proof also of this, the volcanic chain of the earth is around the edge of the Pacific Ocean. Another theory is that about 54,000,000 years ago the earth and moon formed a semi-liquid body. This planet, whose day was but one or two of our hours, rotated rapidly on its axis. The astronomer said that if the earth rotated in three hours it would nearly fly to pieces. The attraction of gravity would be barely strong enough to hold it together, for this is on the same principle that the strength of the iron is insufficient to hold a fly-wheel if spun too fast; after the earth breaks up, gravity holds the pieces together. On account of liquid condition and rapid rotation, the planet became greatly flattened and the equatorial diameters became several times greater than the polar. The primitive planet must have been agitated by solar tides. The moon finally became separated from the earth on account of rapid rotation of the original fluid mass and action of external forces, such as agitation caused by solar tides. At first the moon almost touched the earth's surface, but after several ages the rapidity of rotation was lessened and the distance of moon from earth gradually increased until it finally receded to its present position. Still another theory is that the moon was captured by the earth. Therefore it seems that anyone can accept the theory which appeals most vividly to his imagination.

When at a seashore we see the tides come in and go out. We need no clock to observe this change from day to day, for rocks which

are covered at one time by water during a fortnight, are laid bare at others. The time from one high water to another is about 12 hr. 25 min.; therefore time of high water is delayed about 51 min. daily. This average retardation of the tides is the same as the interval between two successive passages of the moon over the meridian, which is 24 hr. 51 min. Since tides must have a given point from which to start, and the Pacific Ocean is the largest expanse of water, tides are usually supposed to start in the Pacific Ocean and move from east to west. The connection between the moon and tides has been known since the time of Posidonius, but it was Newton who discovered that tides are a direct result of gravitation. Currents which are produced in the sea by tides often become very rough when the open sea is broken by headlands and islets. Earthquakes and other shocks often cause a great wave. A tidal wave is not a free wave, but is a wave which is caused by the continually acting forces of the sun and moon. We see therefore that tide tables are necessary for the pilot to know how the tides are in order to have some knowledge regarding the water, especially where the entrance to the harbor is shallow. If he did not know anything about the tides he might become stranded and thus delay the vessel.

Most astronomers think that the lunar day is so long that it could not support animal or vegetable life. During this long lunar day the moon is subjected to intense heat, enough to heat the surface to or above boiling point. During the long lunar night, which like the lunar day is about two weeks, the heat is radiated rapidly into space and the surface becomes intensely cold.

The atmosphere of the moon, if there is any, is very rare. There are several reasons why it is thought that the moon possesses no atmosphere: The shadows on the moon are very black and the surface and edges of craters are always plainly seen. A star, in passing behind the moon, suddenly disappears, and if there were an atmosphere on the moon a star could be seen for a short time after it had really passed behind its edges. It is also noticeable in an eclipse of the sun, that the edge of the moon, when it passes across the face of the sun, is always clearly outlined. If atmosphere were on the moon the light of the sun would be refracted through it and the moon would be surrounded by a light. There are two ways by which the atmosphere could have departed from the moon. In the first place the vapors of the surface of the moon could have united chemically with other constituents in forming solids, or the atmospheric gases of the moon, by the kinetic theory, could have escaped molecule by molecule from the control of its gravity. If there is no atmosphere on the moon there can be no water, for the simple reason that it would evaporate under the sun's

direct heat and cause atmosphere. It is said that the so-called seas and lakes are but different colored rock formations, as in New Jersey there is a dull red mud and clay in the interior and light bright sand on the coast line. If there ever was water on the moon the earth must have raised tidal waves in the lunar oceans. Some people believe that the lunar oceans have become frozen. The mere fact that the moon is exposed to such intense heat during the lunar day is no reason that we should reject this belief. We have no way of telling how heat would act were there no atmosphere to prevent its immediate and entire reflection into space. We know that in spite of the intense heat which is pouring on the Himalayas the snow remains there century after century. There are several reasons why the atmosphere and water may have departed from the moon's surface. A comet may have carried off the lunar atmosphere and water or these may have passed away to the farther hemisphere of the moon. They might also have been drawn into the cavities of the moon's surface. As to the heat of the moon, it gives very little, and one of the noted astronomers said that it would have to shine on us steadily for one year to give as much heat as the sun gives in one minute. It gives enough light at full moon to enable us to read. In POPULAR ASTRONOMY for November 1914, Professor W. H. Pickering advances his theory concerning the moon. He argues that there may be vegetation on the moon. In presenting his reasons he says that the canals and dark fields do not owe their blackness to shadow. His point is that these markings are invisible at sunrise and sunset and most plainly seen at full moon, while the shadows can be seen at the lunar sunrise and sunset but are absolutely invisible at full moon. Neither can they be due to troughs or ridges, for the outer canals are invisible at sunrise and the inner ones are invisible at sunset. Therefore the blue black color of the fields and canals can be due only to a discoloration of the moon's surface, which is seen during the lunar summer on levels and slopes but is invisible during spring and autumn. Knowing of no mineral which acts in this manner, he supposes that this darkness is due to a covering of vegetation. There are also changes occurring on the surface of the moon. In his opinion if other observers will aid him in the study of these changes on the moon, it will not be long before we will do away with the expression "The moon is a dead planet."

The moon's gravity is one-sixth of the earth's gravity, therefore six pounds on the earth equal one pound on the moon. A volcano on the earth hurling lava one mile would throw it six miles on the moon. The moon looks to be the same size as the sun; the sun is really four hundred times larger in diameter, but four hundred times farther from the earth.

Just as the earth has mountains scattered over its surface so has the moon. But these mountains are packed together without any definite shape or arrangement. These mountains were formed by the wrinkling up of the moon's crust. Great cup-shaped depressions resembling the great volcanic craters of the earth, are known as "craters". An astronomer says that it was formerly thought that these mountains were of volcanic origin; but he thinks that they were caused by the impact of small bodies against the surface of the moon. In his opinion this explains the sunken character of the craters, the great steepness of the inner wall, while the outer wall is of a more gradual slope, and the central peaks, which are the remaining portion of the satellites that produced the craters. It is also suggested that the lunar craters were formed by the impact of meteorites or by the bursting of enormous bubbles, which formerly covered the moon. The largest one on the earth is seven miles, but some on the moon are one hundred miles in diameter. Some peaks are seven miles high and over forty lunar mountains are higher than the highest peak in the United States. There are ten mountain ranges on the moon and about thirty thousand craters. The mountains, which are high and jagged, are more than 20,000 feet high. Their height is due partly to lack of erosion and to the low surface gravity. The height of the mountain is found from the length of the shadow it casts. Besides mountains and craters there are also rays and rills on the moon. They are long streaks which extend outward from Tycho and other large craters and are from five to ten miles wide and several hundred miles long. They cast no shadows and are not interfered with by either valley or mountain. These rays and rills are very brilliant near the center and are brighter as the sun rises higher and higher, that is at the time of full moon. Some people believe these rays to be great cracks with bright colored lava shining up from below; others, that they are lava streams. The rills, which are long cracks on the surface of the moon, are supposed to have been caused by the rapid cooling of the surface or by great volcanic action.

METEORIC ASTRONOMY.

CHARLES P. OLIVIER.

In the past few years there has been quite a revival of interest in the study of meteors as is evidenced both by the formation of at least two new societies for their observation and by the number of papers on this subject which appear in the leading astronomical journals in America and Europe.

At the moment, activity in all branches of science in Europe is greatly curtailed by the war, and hence it seems particularly necessary for observers in this country to attempt to do not only their share, but part of that which under normal conditions would be done abroad. It is the purpose of this paper to point out first, the importance of the systematic observation of meteors and the features of greatest interest connected with them, and secondly, to give some methods by which these observations can be made with the greatest accuracy obtainable. Not pausing to do more than mention the spectacular features offered at times such as great meteoric showers like that of 1833, and the appearance of brilliant fire-balls, which occur every year, we will pass to some of the ways in which the study of meteors bears upon other important astronomical problems.

First in importance, perhaps, is the connection between comets and meteors. Secondly, we may mention that our knowledge of the movements in the upper atmosphere of the earth, how high this atmosphere extends, etc. depends largely upon the study of the drift of meteor trains and the calculation of the heights at which they appear. Hence for the meteorologist this study is of immense importance.

One of the principal theories of evolution depends upon meteoric matter for its basis. The absorption of light in space must take meteors into account. Further, a small amount of the sun's heat is received from this source. We need to know how much this is with more certainty. The constitution of the zodiacal light and the gegenschein is supposed to be meteoric in nature.

Whether the curious behavior of Encke's comet, often explained as due to a resisting medium, is caused by its passage through a locality filled rather densely with meteoric matter is an interesting inquiry. Again the fall of meteoric matter upon the earth brings to us from outer space our only actual specimens of the elements which exist there. Their chemical and geological study forms a branch of science to itself. It is the astronomer's duty, however, to be able to

answer the questions as to their orbits and hence from what part of space they came to us; principally whether they had their origin in our system or really came from interstellar space.

There are other points, but these should suffice to prove that the study of meteors is a branch of astronomy well worth developing.

Taking up the connection of comets and meteors, it is now known that the Perseids, Leonids, Lyrids, η Aquarids and Bielids all are very closely connected with some well known comet.

There are other streams which further work, of an accurate character, will surely prove to have some comet moving in the same orbit. This offers a problem which is of great interest and considerable importance. The study of the numbers of meteors received from such streams as those mentioned, taken in connection with our knowledge—rather limited it is true—as to when the comets became members of our system or at least began to move in their present orbits, gives us our best information as to the amount and results of a comet's disintegration. As at best these bodies furnish so many problems no one can as yet solve, we should be glad to gather all possible information which could aid. It is strange that those professional astronomers, whose interest has been largely taken up with comets, should so rarely have worked in this sister branch, on which the knowledge of the constitution of comets must so largely depend.

The study of meteors, requiring no telescope nor expensive equipment, is above all adapted to the amateur. The only things necessary are a good star map, a lantern, ruler, recording sheet and a pencil. To these simple things there should be added considerable patience in waiting for the meteor to come, and then some rather quick work in getting its path accurately plotted. Accuracy of course increases greatly with practice, but even from the first, any intelligent person, whether a student of astronomy or not, can do something well worth while and actually aid in the increase of our knowledge of meteors.

It is obvious that only by the coöperation of a large number of observers can definitive results be obtained. Therefore an organization is a first necessity.

For this hemisphere the American Meteor Society tries to fill this want. The society is composed of about twenty members, amateurs and professionals, and already has succeeded in securing observations of nearly 4000 meteors. Last year the results of working up the 2800 sent in up to January, 1914, were published in Vol. II, Part 4, Publications of the Leander McCormick Observatory. Among other things 126 parabolic orbits were computed and the proof of the connection of Halley's Comet and the η Aquarid meteors was put beyond any possible

doubt. The form of this publication, the actual preparation of which was undertaken by the author, was based on a former paper by him in which 6200 meteors were discussed.

In recognition of the importance of keeping up the interest in meteoric astronomy and to show their confidence in the work of the American Meteor Society, the National Academy of Sciences, at its recent meeting in Washington, voted a small sum of money from the J. Lawrence Smith fund for meteoric research, which will be available during the coming year to push on and extend the scope of our work and publication. This generous grant will fail in one of its main purposes unless those interested in meteoric astronomy will push their work with renewed enthusiasm.

It gives me pleasure to state that we will shortly have a splendid series of meteor maps for general distribution to our members. These were recently prepared by Dr. Reynold Young of the Dominion Observatory. These maps, 13 in a set, will be furnished free to those who have sent in a fair number of observations, and to all others at the nominal price of ten cents per set.

The record blanks to accompany them, along with full instructions, will be mailed free to all observers.

For the benefit of readers who have never applied for our bulletins and are unfamiliar with the methods of observing meteors, the following instructions are given. It may be well to say that the great detail of these directions does not mean that they are very hard to follow. But an attempt was made to meet every contingency, hence their length and rather complex appearance. A single evening's observing will show the beginner how much easier it is to follow them than it may appear on first reading.

A meteor is observed as follows: Maps are prepared of the region of the sky that is to be especially observed on a given night, care being taken to choose that map whose projection is best for the region in question. On the recording sheets a number of columns are ruled, headed as follows: (1) Time, (2) Number, (3) Class, (4) Color, (5) Magnitude, (6) Length of Path, (7) Duration in tenths of seconds, (8) Duration of Train in tenths of seconds, (9) Remarks, (10) Serial Number, (11) Accuracy. The designations are mostly self explanatory. (2) gives the number of the meteor for the night (10) the serial number for the year—filled in later, (11) the accuracy, on a scale of 3, with which the meteor was observed. Beside the plotted path of the meteor on the map is placed the number for the night and later the serial number in ink. The serial numbers are so arranged that the first figure itself gives the year during which the meteor was seen. Thus 1—117

shows that the meteor was seen in 1901, 9—1,136 in 1909, etc. The methods used to obtain the most accurate plot of a meteor's path are as follows: The greatest case must be taken to obtain the *direction* and any *one* point over which the meteor passed. Often, of course, a meteor's beginning and ending fall exactly at or very near a convenient star, or at such a distance between two near stars that it is easy to estimate the distance proportionally and accurately. In such a case the direction, determined nearly always by holding up a straight rod so that it appears to lie parallel to the meteor's path in the sky, serves mainly as a convenient check.

But in most cases a meteor neither begins nor ends at a point which is easy to determine. Then by glancing backwards and forwards along the rod the eye can always pick up a star in the same great circle. Also there is scarcely ever any difficulty in finding some one point actually in the path itself. As the eye readily estimates the length of path of a meteor with fair accuracy, the parts in front and behind the chosen point can be estimated instantly, and by means of the other reference point entirely outside the path, the meteor's position can be obtained with great accuracy and speed, compared with other methods. By choosing some point behind rather than in front of the path we also in this method eliminate to a great extent the effects of poor projection, which may be troublesome near the edges of almost any map.

It is obvious that the short paths near the radiant are most useful in its determination, both because of their nearness and also their low apparent velocity, which permits of the most accurate plotting. They nearly always have trains also, a most material assistance.

If for any reason certain meteors can not be at once plotted, their paths must be described with such detail that afterwards when put upon maps the results are quite comparable with these plotted at the moment. As far as possible, however, each meteor must be plotted when observed. The best plan is to work up the result partially the next day so that details can be added, when necessary, while the recollection is fresh.

In case an observer, especially a beginner, may feel unable to undertake the full program of work as outlined, he can still do useful work in the following way, at the same time gaining a good knowledge of the constellations and the appearance of meteors, which will eventually aid him greatly. Beginners should be first warned that it is a waste of time to observe on hazy nights or in bright moonlight, for under both these conditions all faint meteors are lost, and, as with stars, faint meteors greatly exceed in numbers the bright ones.

One of the things that it is particularly necessary to know is the rate per hour of meteors for as many different days and as many different

geographical latitudes as possible. Hence if the observer will merely count the number of meteors every half hour, making careful notes at the end of each 30 minutes about the condition of the sky, these results will be very useful. Again all observations of fireballs, meteors of exceptional appearance, long enduring trains, etc. are greatly desired. Such phenomena are frequently noted by astronomers working on other objects than meteors. A request is made to them to send in any such observations in future. And finally any old, unpublished sets of meteor observations, of any year whatever, will be reduced and published, if their owner is willing to lend them to the society for this purpose.

As has been said before, what is needed most of all is observers. We are now in position to furnish any applicant with suitable maps, blank forms and minute directions as to how to carry on the work. The headquarters of the society is at the Leander McCormick Observatory, and all communications relative to the work should be addressed to the author in its care.

With the coming of the summer months especially in late July and all of August, when it is no longer physically uncomfortable to observe, it is hoped that observers will push their work on meteors to the fullest. As there must be many more or less interested in this work who have never made any inquiries as to joining the society, I should like to say that any requests for information will be most gladly answered, and we will welcome any and all amateurs into our ranks. Further it should be stated that as each night's work is complete in itself, even a few scattered nights per year would furnish data which we would be glad to have and which would prove valuable. In our publications each observer will receive the very fullest credit for all the work sent in by him, and copies of our bulletins and reports are mailed to every active member.

Leander McCormick Observatory,
University of Virginia.
May 4, 1915.

SPECTROSCOPIC BINARY IN THE TRAPEZIUM OF ORION.

EDWIN B. FROST.

The preceding star in the trapezium of Orion, known as Bond 619, has long been on our observing program, but it is only lately that I have felt able to take the time to measure the plates available. The measures of our first plate by Frost and Adams yielded a value of +48 km (or fully 30 km in excess of the radial velocity of the nebula) and led us to express the opinion that "It is not impossible that this star varies in its radial velocity."* Rough settings on later plates convinced me of the reality of the change in velocity, but the complication produced by the superposition of the bright nebular lines upon the dark absorption lines, particularly Hβ and Hγ, increased the difficulty of the accurate measurement of the plates. The spectrum corresponds pretty closely to that of type B2, but the lines are broader than in the typical spectrum. The magnitude of the star is 6.8 according to the Harvard photometric measures (*H. A.*, **64**, 168). An exposure of from 2 to 3 hours is required, depending upon the state of the sky.

BOND 619 IN TRAPEZIUM OF ORION.

Plate	Date	G. M. T.	Taken by	No. Lines	Radial velocity
		h m			
287	1904 Mar. 8	15 07	F., S.	8	+48 km
491	1905 Jan. 27	14 25	F., S.	8	+48
497	Feb. 3	14 07	F., S.	5	+61
709	1906 Mar. 5	14 17	F., S.	5	+31
887	Oct. 19	21 53	B., S.	7	+ 4
980	1907 Feb. 15	14 19	F., S.	4	+ 8

B. = Barrett, F. = Frost, S. = Sullivan.

All the plates measured were designated as of good quality.

A range of over 50 kilometers is shown, but there is no indication of the period.

In this connection it is interesting to note that θ^1 Orionis, the brightest star of the trapezium, varies in its velocity, as was surmised by Huggins and confirmed by Frost and Adams. For the following star of the trapezium, Bond 640, also of magnitude 6.8, the last-named observers obtained from 3 plates a velocity of +20 km, hardly in excess of the velocity of the nebula near the trapezium.

* *Astrophysical Journal*, **19**, 355, 1904.

θ^2 Orionis is not in the trapezium, but is the nearest bright star to it (following) within the nebula. It was also found to have a wide range in radial velocity by the writer and Mr. Adams.

From 8 good plates of the nebular spectrum at the star Bond 619 (including the six plates of the above table from which the star's velocity could be determined) the velocity of the nebula at that point was found to be $+15.6 \pm 0.5$ km, from measures by the writer and Mr. C. A. Maney, which will be described more fully in another note.

Yerkes Observatory,
May 14, 1915.

THE POWER OF A TELESCOPE.

W. E. WOOLARD.

A telescope consists of an object-glass which collects rays from any body in front of it and forms a small image of this object according to physical laws. This image is magnified by an eyepiece as though it were a real object. The eyepiece acts as a low-powered microscope. The size of the image does not depend upon the size of the lens as much as upon focal length.* The longer the focal length the larger the image, but as the light forming it is spread over a large surface it is fainter than an image of a short focal length lens. This is important in photographic work where it is of more advantage to have a photograph of a large faint image, requiring a longer exposure than one of a small brilliant image with short exposure, requiring an after enlargement. In photographic work of course the eyepiece is removed and the photograph is of the same size as the original image, which is always comparatively small, even in large telescopes, unless smaller lenses are used to magnify it a few times, as is often done. An unmagnified image of Mars in the Yerkes telescope is about one-eleventh of an inch across. Of course this article applies to specula as well as lenses. But in some things, as the scrutiny of the moon's surface, visual work is ahead of photographic, and in visual work the size of the image is not as important as its brightness.

* The focal length of a lens depends upon the curvature of its surfaces, not its diameter. If ordinary proportions are given to the lens, the focal length becomes a function of the diameter.

Why is a large telescope more effective than a small one? The sizes of the images do not differ enough to make much difference. It is only after we have magnified the image of the objective by an eyepiece that we can see anything, and every telescope has a whole battery of eyepieces of different magnifying powers. The more we magnify an image the larger it becomes of course, the better we can see the details, and the more we can see—in other words it brings the object closer apparently and the closer we are to anything the better we can see it. Of course as the image is magnified, the total amount of it that we can see at any one time decreases. Now why can't we magnify the image of a small lens until we get it as large as the magnified image of a large lens and consequently be able to see just as much? We will undertake to answer this question.

Every point of an object sends out rays in every direction to an infinite distance if not stopped by an opaque object, and consequently to every point on the lens. As points have position only, the number of rays is infinite, and in passing through the lens all these rays are refracted to a point. Thus as each point is at a different place in the object, and consequently in the image, and since the image of each point resembles the real point, an image of the object is formed. Now only those rays which strike the lens go into the image, which is of a certain brightness, and it is clear that if more rays went into it, the image would be brighter. But the only way more rays could be caused to take part in forming the image would be to increase the size of the lens, consequently the light-gathering surface, as shown easily by a diagram. Therefore the larger the lens the brighter the image, as more light is made to take part in forming the image. But what has this got to do with magnifying power?

In magnifying an object it is made larger, but the quantity of light necessarily remains constant. Consequently the original illumination has to spread over a greater surface and the object grows apparently fainter. The higher the magnifying power the fainter the object grows, until finally it becomes so faint and indistinct that it cannot be observed. Furthermore the imperfections of instrument and atmosphere are also magnified. Therefore the brighter the image in a telescope, that is, the larger the objective, the higher the power that can be used advantageously, the closer the object can be brought, and the more can be discerned.

If a telescope had an objective one-fifth of an inch in diameter we could see no more with it than with the eye, because it would grasp no more light. But if it were one hundred inches in diameter, or five hundred times that of the pupil of the eye in the dark, it would grasp 250,000 times as much light as the eye, since the areas of two circles

are to each other as the squares of their diameters. Hence, we could see 250,000 times as far, since it would bring things that many times as close. As a matter of fact, eighteen per cent of the light is lost in a refractor. One advantage of large instruments, and an important one, lies also in their great focal length. For it is easily seen that for a given diameter, the image is larger the greater the focal length, although the image is always so small that the question of brightness and ability to stand magnification is very important in visual work, as explained above. But in photographic work the focal length is often enormously increased by combinations of mirrors and lenses, so that there is obtained a very large, though faint image. Ritchey has thus photographed our satellite with a focal length of 150 metres. However, the larger an image of a given brightness is to start with, the more advantageous it is for visual work, particularly for certain lines of astronomical work. For some things a large telescope is not desirable.

So now to sum up: The *larger* the *objective*, and consequently the *telescope* and *focal length*, the more light it collects, and the *brighter* and *larger* the telescope's *image*. Consequently, the more the image can be *magnified*, and still remain distinct, that is, the *closer* it can be brought, the more of detail can be seen in it.

It is thus simply a question of magnification, or in photography, exposure, depending upon the light-grasping power or diameter of the objective. As far as geometrical theory goes we can see as much with a small telescope as with a large one, for by putting a physician's microscope onto a four-inch telescope we could make it as powerful as Herschel's reflectors. But in practice this is impossible for the following reasons:

First, the image would be so faint and imperfect that nothing in it could be made out, for atmospheric and instrumental imperfections are correspondingly magnified. Second, the effect of light having a wave-length is such as to give no advantage in using a magnifying power of over 50 or 100 for each inch of aperture. Third, as achromatism is not perfect, the increase of the aureoles sets a limit, and of course the numerous imperfections also set a very low limit. In practice, it is seldom possible to use a power of over thirty for each inch of aperture.

THE ZODIACAL LIGHT. ITS PLACE IN THE SOLAR SYSTEM.

Rev. W. E. GLANVILLE, Ph. D.

(1) The theory that the zodiacal light is a nebulous ring surrounding the sun is, for the most part, no longer held. It was Baron von Humboldt's theory and Sir John Herschel wrote: "I cannot imagine upon what grounds Humboldt persists in ascribing it to the form of a ring encircling the sun." For dynamical and optical reasons we believe this theory to be untenable.

(2) The theory that it is a solar appendage has received more support and in fact remains the theory most generally accepted. It was originated by Giovanni Domenico Cassini at the Royal Observatory, Paris, about 1685. But it is hard to conceive what form such an appendage can take reaching out from the sun to a distance exceeding the earth's orbit. At Pike's Peak in 1878 during a solar eclipse Professor Langley observed the long coronal streamers extending to a distance estimated at 10,000,000 miles, and the question has been asked: May not the corona in increasingly attenuated form extend 93,000,000 miles? Apart from the fact that the appearance of the Zodiacal Light does not correspond with that of the corona, Laplace declared that the sun's atmosphere "can extend no farther than to the orbit of a planet whose periodical revolution is performed in the same time as the sun's rotary motion on its axis, i.e., only $\frac{9}{2}_0$ of Mercury's distance from the sun." There is no evidence that the coronal streamers extend even to the orbit of Mercury.

Moreover, if the Zodiacal Light is a solar appendage of the kind supposed, reaching forth unbrokenly from the sun, it must create a resisting medium involving Mercury, Venus, the earth and the moon and of this there is no evidence. A variant of this theory invokes Arrhenius's doctrine of light-pressure, by which it is surmised that streams of electrons expelled from the photosphere are light-borne to a distance just exceeding the earth's orbit and there held in unstable equilibrium. This is a fanciful speculation and, without prejudice to the applicability of Arrhenius's doctrine to the relationship between solar electrical action and terrestrial magnetism, it may be stated that there is no evidence that the zodiacal light can be thus accounted for. The conception of a lenticularly-shaped envelop which is usually connected with the solar appendage theory arose in my opinion, from the lenticularly-shaped appearance of the zodiacal light as frequently observed.

But this conception is rendered valueless by the fact that *the illuminated part of the Zodiacal Light band does not exhibit the whole of the Zodiacal Light band material at any one and the same time.*

(3) The third outstanding theory to account for the Zodiacal Light is that it is an earth ring, comparable, say, to the "crape" ring of Saturn

By using the word "comparable" it is not intended that the Zodiacal Light band corresponds *in every respect* to the crape ring of Saturn. Variety in similarity appears to be Nature's method. Saturn's ring system is situated in the line of the planet's equator. The Zodiacal Light band follows the line of the ecliptic and maintains with respect to the Sun's illumination a uniform appearance the year round, but as viewed by an observer on a fixed station the light changes in direction and intensity in the course of the year, according as the angle made with the horizon is more oblique or more nearly approaches a right angle. The points of resemblance suggested by the word "comparable" are (1) that, like Saturn's "crape ring", the Zodiacal Light band is a planetary ring and (2) that, like the crape ring, it is well-nigh transparent.

After the famous Leonid display of 1833 a discussion arose on the possibility of the Zodiacal Light being the origin of meteors. In the course of that discussion J. C. Houzeau contributed a paper to the *Astronomische Nachrichten* in which (as the result of his own observations) he argued that the causes of the Zodiacal Light may be "more local than has been hitherto supposed." A few months ago a well-known English astronomer, knowing of my interest in Zodiacal Light investigation, wrote me that no definite, stable results can be obtained concerning the place of the Zodiacal Light in the Solar System "until we have a continuous series of observations on both sides of the equator." Presumably he was not aware that such a series had been made. From April 2, 1853 to April 12, 1855, Sundays excepted, for every day of good observing weather, the Rev. George Jones A. M., U. S. N., chaplain of the U. S. Japan Expedition, made observations of the Zodiacal Light. His report, comprising notes made at the time of each observation, accompanied by carefully drawn charts, was published by authority of Congress as a government document and forms volume III of the report of the U. S. Japan Expedition under the command of Commodore W. C. Perry. The work is now out of print; in fact, only one impression was made. Chaplain Jones was not a professional astronomer but he was a man of scholarly aptitudes, of masculine common sense, and his skill and trustworthiness are generously attested by the professors of astronomy and mathematics of that day at Harvard, Yale and the U. S. Naval Academy. Moreover, when any unusual phenomena occurred in the course of his investigations he

sought the criticism or confirmation of his judgment from naval officers attached to the expedition, part of whose training at the Academy consisted of Nautical Astronomy; he also sought the aid of petty officers who doubtless were men of keen and practiced eyesight—and for the observation of Zodiacal Light phenomena no instrumental agency is required apart from the unaided eye. Under no better conditions could a series of observations possibly be made, and the length of time, extending over two years, in both the eastern and western hemispheres, N. and S. of the equator, from 41° 50′ N. (near Hakodadi, Japan) to 53° 38′ S. (Straits of Magellan), permitted of as diversified a study of the Zodiacal Light as could be desired. Of the 328 observations reported and charted, 148 were made in the tropics. An inspection of the charts is conclusive of their veracity. On each chart is marked the horizon line for each observation (sometimes three or four on the same evening or morning); the ecliptic line is marked, also the place of the sun on the ecliptic below the horizon showing the angle between the sun and the horizon; the outline of the stronger part of the light for each observation is drawn with reference to conspicuous stars or planets and a dotted line surrounding this shows the extent of what Chaplain Jones calls the Diffuse Light spreading N. and S. of the stronger band as far as he could see it.

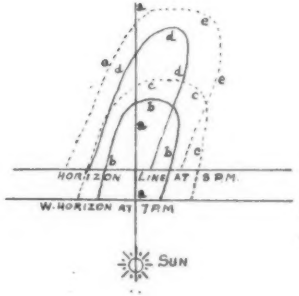


FIGURE. 1. ILLUSTRATING CHAPLAIN JONES'S METHOD OF CHARTING HIS OBSERVATIONS.

aaa Ecliptic line; *bbb* Stronger light at 7 p. m.; *ccc* Diffuse light at 7 p. m.; *ddd* Stronger light at 8 p. m.; *eee* Diffuse light at 8 p. m.

This illustration is drawn for observations made at a position on the earth N. of the ecliptic line, the reflection showing to the north. With the ecliptic line stretching over the observer's head the illumination of the Zodiacal Light band is fairly evenly divided N. and S. of the ecliptic. For positions S. of the ecliptic line the illumination shows more fully to the south. All of which is abundantly exhibited by Chaplain Jones's charts.

Of Chaplain Jones's competency as an observer there can be no doubt. As an intelligent man, realizing that he was engaged in a department of research for which the scientific world waited, absolutely conscientious in his determination to report facts, he is certainly entitled to have his report considered dispassionately.

Among other interesting special features of his report we note the shifting of the Zodiacal Light, as projected against the starry sky, from hour to hour; but always along the ecliptic; the gegenschein* visible in the east in the evening; the Moon Zodiacal Light in the evening in the east prior to moonrise; the joint Sun and Moon Zodiacal Light, seen in the west in the evening, the moon being at first quarter; the simultaneous eastern and western Zodiacal Lights, seen in favorable latitudes, the cone of light reaching up from both E. and W. horizons about midnight, the eastern light growing stronger as the western light fails; the pulsations of the light due either to atmospheric conditions or to commotions in the Zodiacal Light band material; the varying brightness of the gegenschein sometimes well-defined, at other lines quite elusive and much elongated, due to change of angle of reflection in the course of the year.

While strenuously resolved not to begin his observations with any preconceived theory of the place of the Zodiacal Light in the Solar System, Chaplain Jones states that after a few month's observations, strive as he might, he could not banish the thought that it is an earth ring and this thought ripened into conviction by the time the cruise ended.

Present-day astronomers are generally agreed that the Zodiacal Light is at no great distance from the earth; that, as is said, there is something "familiar" about it. A careful perusal of Chaplain Jones's data, illustrated by his charts, leads one—no less than he was led when actually making the observations—to the conclusion that the theory of the Zodiacal Light being an earth-ring fits the facts more fully than any other theory. Especially the relation of the reflected moonlight in the eastern evening sky to the Zodiacal Light band; the presence at midnight of both eastern and western lights; the uniformly broad base of the light along the horizon, narrowing and sometimes tapering towards the observer's meridian circle; all of these facts considered in connection with the laws of the reflection of light argue a circularly or ellip-

* On his return to America Chaplain Jones published an account of this eastern evening light which called forth a letter from Mons. Theo. J. C. A. Brorsen of Serptenberg, Germany, who stated that he had seen it regularly during the two previous years and named it the "Gegenschein"—a term used for it ever since. Mons. Brorsen also affirmed his conviction that the "Gegenschein" always occupied the place exactly opposite to the sun in the sky—a conviction fully verified.

tically curved band at no remote distance from the earth, from which the light is reflected according to the angle of incidence.

Why, then, it may be asked, has not Chaplain Jones's conclusion won acceptance?

It is my judgment that the theory of a ring of nebulous or meteoric matter surrounding the earth was held untenable because, if the Zodiacal Light band were such a ring, the light would be *strongest directly behind the earth* as in the case of the full moon.* It is, I venture to believe, this consideration which has led astronomers to reject the earth ring theory. Whether Chaplain Jones knew that such an objection (*prima facie* fatal to his conclusion) would be urged I do not know. He nowhere makes any reference to it in his report. Can this crucial objection be removed? It is unanimously conceded that there is a dimming of the Zodiacal Light directly behind the earth. At times nothing can be seen of it, at other times the gegenschein can be made out. The question naturally arises: Why is the Zodiacal Light dimmed (at times invisible) right behind the earth? My answer is: *The earth's shadow falls athwart it.* The Zodiacal Light lies along the ecliptic—i.e. runs along the signs of the zodiac, the zodiacal constellations;—therefore, if within the range of the earth's shadow, it must thereby be dimmed. Lying on the ecliptic, the central part, so to speak, of the Zodiacal Light band is *exactly in the place of a full moon totally eclipsed.*

This, I beg to submit, is an adequate explanation of the reason why the Zodiacal Light is not strongest directly behind the earth. Accepting this reasonable explanation the crucial objection to the earth ring theory is demolished and the theory itself is strengthened to the point of demonstration. Further objection may be urged that if the Zodiacal Light band be an earth-ring the illumination should be strong and clear-cut right to the point where the earth's shadow intervenes. In considering this objection I suggest that allowance should be made for the penumbra section of the earth's shadow which should have the effect of *diminishing* the brilliancy of the Zodiacal Light as it approaches the umbra. The persistence of the light through the penumbra and even into the umbra, though dimly and more narrowly, as reported from observations in the tropics seems to indicate that the Zodiacal Light material may be more agglomerated along the axis of the band.

On account of the feeble intensity of the light spectroscopic examination is very difficult and a specially designed spectroscope—such as

* By "directly behind the earth" is meant the point of the sky exactly opposite to the sun, e. g. at midnight.

Dr. Michie Smith's at Kodaikanal—is desired. Recent work by Professor Fath at Lick and Mt. Wilson corroborates previous examinations to the extent of affirming that the light is reflected sunlight.

It may therefore be affirmed that the theory of the Zodiacal Light being a planetary ring is in good standing and that the preponderance of evidence is in its favor.

St. Peter's Rectory,
Solomons, Md. 1915 March 15.

PLANET NOTES FOR JULY AND AUGUST, 1915.

The sun will be moving south and east during this period. It will move from Gemini, through Cancer, and into Leo. On August 21 it will pass very near the bright star Regulus. On August 10 there will be the second annular eclipse of the sun for this year. This eclipse however will not be visible in the United States. The region of visibility is almost entirely confined to the Pacific Ocean. It will be visible in the Phillipine Islands, in Japan and in eastern China.

The phases of the moon for these months are as follows:

Last Quarter	July	3	at	12 P.M.	C.S.T.
New Moon		12	"	10 A.M.	"
First Quarter		19	"	3 P.M.	"
Full Moon		26	"	6 A.M.	"
Last Quarter	Aug.	2	at	3 P.M.	C.S.T.
New Moon		10	"	5 P.M.	"
First Quarter		17	"	8 P.M.	"
Full Moon		24	"	4 P.M.	"

Mercury will be moving westward from the sun at the beginning of the month. On July 18 it will reach its greatest angular distance from the sun. On this date this planet will appear on the eastern horizon at about the same point as the sun, but an hour and a half earlier. It therefore can be observed on and near this date just before sunrise. It will then move toward the east more rapidly than the sun and will overtake the sun on August 17 and pass it on the opposite side from the earth. By the end of August it will be about an hour east of the sun and a few degrees south of it.

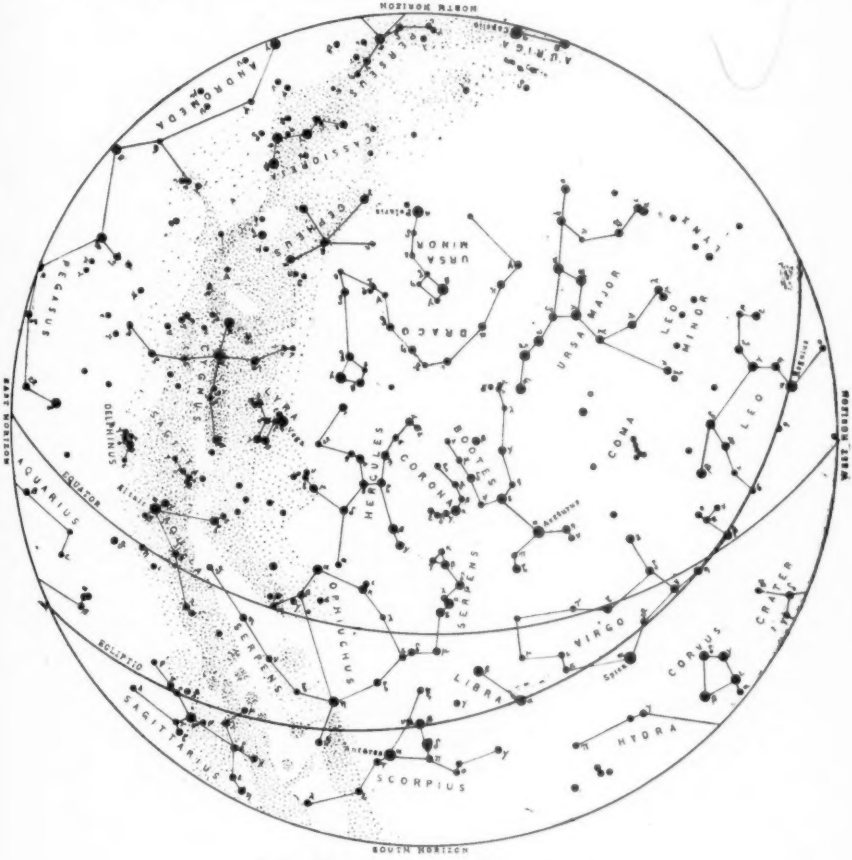
Venus will continue to move eastward throughout this period. It will be moving a little more rapidly than the sun. At the beginning of July it will rise about an hour and a half before the sun and at the end of August only a few minutes before the sun. It will be practically invisible after the middle of July. Although almost the entire illuminated disk will be turned toward the earth it will not be at its greatest brilliancy because of its remoteness. It will be moving around to the side of the sun opposite the earth.

The earth will be at its greatest distance from the sun for the year on July 5.

Mars will be visible in the eastern sky in the early morning throughout this period. The sun will be moving toward the east leaving Mars behind. About the

middle of July it will be passing between the Pleiades and Aldebaran. At the beginning of the period it will be about 186 million miles from the earth and will move to a position of only 163 million miles distance by the end of the period. It will be of about the first magnitude during these two months.

Jupiter will rise a little before midnight at the beginning and a little before sunset at the end of this period. During July therefore it will be favorably situated for evening observation.



THE CONSTELLATIONS AT 9:00 P. M. JULY 1.

Saturn will just be emerging from behind the sun on July 1. By the end of August it will be well up in the sky at sunrise and may then be observed.

Uranus will be in its most favorable position, being in opposition on August 6. On July 26 at $15^h\ 28^m$ Washington Mean Time, Uranus will be occulted by the moon.

Neptune will be too near the sun to be observed during these two months. It will be in conjunction with the sun on July 23.

Phenomena of Jupiter's Satellites.

[Visible at Washington.]

CENTRAL STANDARD TIME.

		h	m		
July	3	12	13	III	Ec. Dis.
	3	14	12	IV	Ec. Re.
	5	12	11	II	Sh. In.
	5	14	58	II	Tr. In.
	5	15	2	I	Sh. In.
	5	15	4	II	Sh. Eg.
	6	12	16	I	Ec. Dis.
	7	10	51	I	Tr. In.
	7	11	48	I	Sh. Eg.
	7	12	29	II	Oc. Re.
	7	13	7	I	Tr. Eg.
	12	12	23	IV	Tr. Eg.
	12	14	48	II	Sh. In.
	13	14	10	I	Ec. Dis.
	14	11	24	I	Sh. In.
	14	11	28	III	Tr. In.
	14	12	41	I	Tr. In.
	14	13	42	I	Sh. Eg.
	14	14	20	III	Tr. Eg.
	14	14	56	II	Oc. Re.
	14	14	58	I	Tr. Eg.
	15	12	10	I	Oc. Re.
	21	10	8	III	Sh. In.
	21	12	12	II	Ec. Dis.
	21	13	17	I	Sh. In.
	21	13	21	III	Sh. Eg.
	21	14	30	I	Tr. In.
	21	15	11	III	Tr. In.
	22	10	33	I	Ec. Dis.
	22	14	0	I	Oc. Re.
	23	9	36	II	Sh. Eg.
	23	10	4	I	Sh. Eg.
	23	11	14	I	Tr. Eg.
	23	11	59	II	Tr. Eg.
	28	14	8	III	Sh. In.
	28	14	47	II	Ec. Dis.
	28	15	11	I	Sh. In.
	28	15	22	IV	Sh. In.
	29	12	27	I	Ec. Dis.
	30	9	22	II	Sh. In.
	30	9	40	I	Sh. In.
	30	10	45	I	Tr. In.
	30	11	36	II	Tr. In.
	30	11	57	I	Sh. Eg.
	30	12	14	II	Sh. Eg.
	30	13	2	I	Tr. Eg.
	31	14	24	II	Tr. Eg.
	31	10	15	I	Oc. Re.
Aug.	1	11	28	III	Oc. Re.
	5	14	22	I	Ec. Dis.
	6	9	3	IV	Oc. Dis.
	6	10	42	IV	Oc. Re.
	6	11	33	I	Sh. In.
	6	11	59	II	Sh. In.
	6	12	32	I	Tr. In.
	6	13	51	I	Sh. Eg.
	6	13	59	II	Tr. In.
	6	14	48	I	Tr. Eg.
	6	14	51	II	Sh. Eg.
Aug.	7	8	50	I	Ec. Dis.
	7	12	2	I	Oc. Re.
	8	9	15	I	Tr. Eg.
	8	11	15	II	Oc. Re.
	8	11	19	III	Ec. Re.
	8	12	11	III	Oc. Dis.
	8	14	58	III	Oc. Re.
	13	13	27	I	Sh. In.
	13	14	18	I	Tr. In.
	13	14	37	II	Sh. In.
	13	15	45	I	Sh. Eg.
	14	9	40	IV	Sh. In.
	14	10	45	I	Ec. Dis.
	14	13	7	IV	Sh. Eg.
	14	13	48	I	Oc. Re.
	15	8	44	I	Tr. In.
	15	9	13	II	Ec. Eis.
	15	10	14	I	Sh. Eg.
	15	11	0	I	Tr, Eg.
	15	12	20	III	Ec. Dis.
	15	13	33	II	Oc. Re.
	15	15	20	III	Ec. Re.
	15	15	38	III	Oc. Dis.
	16	8	15	I	Oc. Re.
	17	8	18	II	Tr. Eg.
	19	8	1	III	Tr. Eg.
	20	15	21	I	Sh. In.
	21	12	40	I	Ec. Dis.
	21	15	34	I	Oc. Re.
	22	9	50	I	Sh. In.
	22	10	29	I	Tr. In.
	22	11	48	II	Ec. Dis.
	22	12	8	I	Sh. Eg.
	22	12	45	I	Tr. Eg.
	22	15	50	II	Oc. Re.
	23	10	0	I	Oc. Re.
	24	7	49	II	Tr. In.
	24	9	26	II	Sh. Eg.
	24	10	36	II	Tr. Eg.
	26	8	36	III	Tr. In.
	26	9	20	III	Sh. Eg.
	26	11	22	III	Tr. Eg.
	28	14	34	I	Ec. Dis.
	29	11	44	I	Sh. In.
	29	12	13	I	Tr. In.
	29	14	1	I	Sh. Eg.
	29	15	23	II	Ec. Dis.
	29	14	29	I	Tr. Eg.
	30	9	3	I	Ec. Dis.
	30	11	45	I	Oc. Re.
	31	7	15	IV	Sh. Eg.
	31	8	30	I	Sh. Eg.
	31	8	55	I	Tr. Eg.
	31	8	55	IV	Tr. In.
	31	9	12	II	Sh. In.
	31	10	6	II	Tr. In.
	31	10	25	IV	Tr. Eg.
	31	12	3	II	Sh. Eg.
	31	12	53	II	Tr. Eg.

Note:—In., denotes ingress; Eg., egress; Dis., disappearance; Re., reappearance, Ec., eclipse; Oc., occultation; Tr., transit of the satellite; Sh., transit of the shadow.

Occultations Visible at Washington.

Date 1915	Star's Name	Magnitude	IMMERSION. Washington M.T.	IMMERSION. Angle f'm N.	EMERSION. Washington M.T.	EMERSION. Angle f'm N.	Duration
			h m	°	h m	°	h m
July 2	25 Piscium	6.2	10 22	36	11 12	270	0 50
23	10 G Sagittarii	5.7	11 8	16	11 40	327	0 32
26	Uranus	6.0	15 28	42	16 31	252	1 4
28	252 B Aquarii	5.8	15 26	47	16 41	234	1 16
28	197 G Aquarii	6.3	16 51	95	17 43	192	0 52
Aug. 7	52 Geminorum	6.1	15 21	53	16 6	311	0 45
21	*h* Sagittarii	4.7	7 12	68	8 30	263	1 18
21	51 Sagittarii	5.8	7 15	18	7 54	316	0 39
23	42 Capricorni	5.1	13 57	90	14 52	201	0 55
28	101 Piscium	6.2	10 0	343	10 10	322	0 10
29	26 Arietis	6.2	13 26	67	14 47	228	1 21

VARIABLE STARS.

Approximate Magnitudes of Variable Stars of Long Period on May 1, 1915.

[Communicated by the Director of Harvard College Observatory, Cambridge, Mass.]

Name.	R. A. 1900.	Decl. 1900.	Magn.	Name.	R.A. 1900	Decl. 1900	Magn.
	h m	° ′			h m	° ′	
S Cassiop.	1 12.3	+72 5	9.5*d*	R Cancri	8 11.0	+12 2	8.5 *i*
Y Persei	3 20.9	+43 50	10.1	V Cancri	16.0	+17 36	8.2 *i*
R Persei	23.7	+35 20	10.1*d*	T Lyncis	16.4	+33 51	11.5*d*
W Tauri	4 22.2	+15 49	9.6 *i*	RT Hydrae	24.7	− 5 59	7.8
R Tauri	22.8	+ 9 56	<13.0	S Hydrae	48.4	+ 3 27	8.5*d*
X Camelop.	32.6	+74 56	12.5	T Hydrae	50.8	− 8 46	9.1*d*
RX Tauri	32.8	+ 8 9	12.5	T Cancri	51.0	+20 14	8.7 *i*
V Tauri	46.2	+17 22	<13.0	R Leo. Min.	9 39.6	+34 58	9.9*d*
V Orionis	5 0.8	+ 3 58	8.8	R Leonis	42.2	+11 54	9.2*d*
R Aurigae	9.2	+53 28	8.1	Y Hydrae	46.4	+22 33	6.5
W Aurigae	20.1	+36 49	<12.0	V Leonis	54.5	+21 44	11.4*d*
S Aurigae	20.5	+34 4	9.0	R Urs. Maj.	10 37.6	+69 18	8.6*d*
U Aurigae	35.6	+31 59	<12.0	W Leonis	48.4	+14 15	<12.0
U Orionis	49.9	+20 10	7.5 *i*	S Leonis	11 5.7	+ 6 0	11.6 *i*
X Aurigae	6 4.4	+50 15	<11.0	R Coma. Ber.	59.1	+19 20	<12.0
S Lyncis	35.9	+58 0	11.1*d*	SU Virginis	12 0.0	+12 56	<12.0
X Gemin.	40.7	+30 23	12.0*d*	T Virginis	9.5	− 5 29	10.4*d*
Y Monoc.	51.3	+11 22	8.6	R Corvi	12 14.4	−18 42	8.0 *i*
R Lyncis	53.0	+55 28	10.2*d*	SS Virginis	20.1	+ 1 19	7.9*d*
R Gemin.	7 1.3	+22 52	12.9	Y Virginis	28.7	− 3 52	<12.0
R Can. Min.	3.2	+10 11	8.9 *i*	T Urs. Maj.	31.8	+60 2	12.1*d*
V Gemin.	17.6	+13 17	<12.0	R Virginis	33.4	+ 7 32	7.4 *i*
S Can. Min.	27.3	+ 8 32	10.5*d*	RS Urs .Maj.	34.4	+59 2	10.7*d*
T Can. Min.	28.4	+11 58	13.0	S Urs. Maj.	39.6	+61 38	8.6 *i*
U Can. Min.	35.9	+ 8 37	11.9*d*	RU Virginis	42.2	+ 4 42	<12.0
S Gemin.	37.0	+23 41	<13.0	UV irginis	46.0	+ 6 6	9.6*d*
T Gemin.	43.3	+23 59	12.2	V Virginis	13 22.6	− 2 39	<12.0
U Puppis	56.1	−12 34	<12.0	S Virginis	27.8	− 6 41	10.2*d*

Approximate Magnitudes of Variable Stars of Long Period on May 1, 1915—Continued.

Name.	R. A. 1900. h m	Decl. 1900. ° ′	Magn.	Name.	R.A. 1900. h m	Dec. 1900. ° ′	Magn.
R Can. Ven.	13 44.6	+40 2	9.4*d*	S Herculis	16 47.4	+15 7	8.6 *i*
U Urs. Min.	14 15.1	+67 15	10.4*d*	RT Herculis	17 6.8	+27 11	<11.0
S Bootis	19.5	+54 16	<11.0	RS Herculis	17.5	+23 1	8.2
R Camelop.	25.1	+84 17	12.5 *i*	T Herculis	18 5.3	+31 0	10.9*d*
V Bootis	25.7	+39 18	8.8*d*	W Lyrae	11.5	+36 38	<12.0
R Bootis	32.8	+27 10	8.1*d*	R Cygni	19 34.1	+49 58	8.2 *i*
S Serpentis	15 17.0	+14 40	<11.0	RT Cygni	40.8	+48 32	7.4
S Cor. Bor.	17.3	+31 44	8.6*d*	χ Cygni	46.7	+32 40	10.4*d*
S Urs. Min.	33.4	+78 58	9.5 *i*	Z Cygni	58.6	+49 46	8.9 *i*
V Cor. Bor.	46.0	+39 52	8.9*d*	S Cygni	20 3.4	+57 42	<11.0
R Serpentis	46.1	+15 26	6.7 *i*	ST Cygni	29.9	+54 38	<11.0
R Herculis	16 1.7	+18 38	9.4*d*	V Cygni	38.1	+47 47	<11.0
RU Herculis	6.0	+25 20	9.3*d*	T Delphini	40.7	+16 2	9.3 *i*
U Herculis	21.4	+19 7	7.0	T Cephei	21 8.2	+68 5	10.2*d*
SS Herculis	28.0	+ 7 3	9.3*d*	S Cephei	36.5	+78 10	<11.0
W Herculis	31.7	+37 32	9.8 *i*	RU Cygni	37.3	+53 52	8.0
R Draconis	32.4	+66 58	12.4				

The letter *i* denotes that the light is increasing; the letter *d*, that the light is decreasing; the sign <, that the variable is fainter than the appended magnitude.

The above magnitudes have been compiled at the Harvard College Observatory from observations made by the following observers:— L. Barbour, T. C. H. Bouton, A. B. Burbeck, H. O. Eaton, G. L. Harrell, J. B. Lacchini, C. B. Lindsley, O. Mach, C. Y. McAteer, C. S. Mundt, W. T. Olcott, D. B. Pickering, C. F. Richter, F. H. Spinney, H. M. Swartz, H. W. Vrooman, I. E. Woods, and A. S. Young.

Maxima of Variable Stars of Short Period.

[Calculated by Julia M. Hawkes and Agnes E. Wells at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time. To obtain Eastern standard time subtract 5h; Central standard time 6h; etc.

Star	R. A. 1900 h m	Decl. 1900 ° ′	Magnitude	Approx. Period d h	Greenwich mean times of maxima in 1915. July d h	d h	Aug. d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.4	36 13.7		12 3		17 17
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 1.7	8 7;	24 14;	1 17,	18 0
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	3 11;	18 22;	3 10;	18 21
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2	9 12;	24 7;	8 2;	22 22
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	7 19;	23 16;	8 13;	24 10
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	3 11;	19 1;	3 15;	19 6
TU Persei	3 01.8	+52 49	11.4—12.2	0 14.6	4 17;	19 7;	9 3;	24 17
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0	10	26	11	27
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	6 13;	23 17;	1 7;	18 11
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	11 19;	22 23;	3 2;	25 8
RX Aurigae	4 54.5	+39 49	7.2— 8.1	11 15.0	8 7;	19 22;	12 4;	23 19
SX Aurigae	5 04.6	+42 02	8.0— 8.7	1 12.8	7 22;	23 5;	7 13;	22 20
SY Aurigae	05.5	+42 41	8.4— 9.5	10 03.3	2 22;	23 4;	2 7;	22 14
Y Aurigae	21.5	+42 21	8.6— 9.6	3 20.6	5 8;	20 18;	5 5;	20 15
RZ Gemin.	5 56.6	+22 12	9.1—10.0	5 12.7	11 4;	22 5;	2 6;	18 20
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	1 19;	16 22;	1 2;	23 18
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	2 15;	29 15;		25 15
RZ Camelop.	23.7	+67 06	11.0—13.0	0 11.5	6 12;	20 22;	4 8;	18 18
W Gemin.	6 29.2	+15 24	6.7— 7.5	7 22.0	4 16;	20 12;	5 7;	21 3
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	13 21;	24 1;	3 5;	23 12
RU Camelop.	7 10.9	+69 51	8.5— 9.8	22 06.5		14 6;	5 13;	27 19

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of maxima in 1915. July				Aug.			
	h m	° ′		d h	d	h	d	h	d	h	d	h
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	5	21;	21	19;	6	16;	22	13
V Carinae	8 26.7	−59 47	7.4— 8.1	6 16.7	5	3;	18	13;	7	15;	21	0
T Velorum	8 34.4	−47 01	7.6— 8.5	4 15.3	3	14;	22	4;	9	17;	28	7
V Velorum	9 19.2	−55 32	7.5— 8.2	4 08.9	7	8;	16	2;	2	13;	20	1
Z Leonis	9 46.4	+27 22	7.9— 9.6	59 0.0					6			
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	1	18;	15	8;	4	16;	18	6
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	2	3;	15	18;	4	4;	17	9
S Muscae	12 07.4	−69 36	6.4— 7.3	9 15.8	9	4;	28	12;	7	4;	26	11
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	7	13;	23	12;	8	11;	24	10
T Crucis	15.9	−61 44	6.8— 7.6	6 17.6	4	9;	24	14;	7	1;	20	12
R Crucis	18.1	−61 04	6.8— 7.9	5 19.8	4	8;	21	19;	2	11;	14	2
S Crucis	12 48.4	−57 53	6.5— 7.6	4 16.6	3	22;	18	0;	1	2;	19	20
W Virginis	13 20.9	− 2 52	8.7—10.4	17 06.5	8	12,	25	18;	12	1;	29	7
SS Hydrae	25.0	−23 08	7.4— 8.1	8 4.8	4	10;	20	19;	6	5;	22	14
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	4	20;	18	21;	1	22;	22	23
ST Virginis	14 22.5	− 0 27	10.3—11.4	0 09.9	1	8;	17	18;	3	4;	19	14
V Centauri	25.4	−56 27	6.4— 7.8	5 11.9	5	7;	21	18;	1	18;	18	5
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	1	17;	16	19;	8	11;	23	13
RU Bootis	14 41.5	+23 44	12.8—14.3	0 11.9	3	16;	18	12;	9	18;	24	14
R Triang. Austr.	15 10.8	−66 08	6.7— 7.4	3 09.3	2	20;	23	4;	5	17;	19	7
S Triang. Austr.	15 52.2	−63 29	6.4— 7.4	6 07.8	3	14;	22	13;	4	5;	16	20
S Normae	16 10.6	−57 39	6.6— 7.6	9 18.1	6	22;	26	10;	5	4;	24	16
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	6	0;	23	18;	1	14;	19	8
RV Scorpii	16 51.8	−33 27	6.7— 7.4	6 01.5	3	2;	21	6;	2	9;	14	12
X Sagittarii	17 41.3	−27 48	4.4— 5.0	7 00.3	6	12;	20	12;	3	13;	17	13
Y Ophiuchi	47.3	− 6 07	6.1— 6.5	17 02.9			16	21;	3	0;	20	2
W Sagittarii	17 58.6	−29 35	4.3— 5.1	7 14.3	2	14;	17	18;	1	23;	17	3
Y Sagittarii	18 15.5	−18 54	5.4— 6.2	5 18.6	3	16;	15	6;	1	13;	18	21
U Sagittarii	26.0	−19 12	6.5— 7.3	6 17.9	2	14;	16	2;	5	7;	18	19
Y Scuti	32.6	− 8 27	8.7— 9.2	10 08.3	4	17;	25	9;	4	18;	25	10
Y Lyrae	34.2	+43 52	11.3—12.3	0 12.1	3	15;	21	17;	2	19;	14	20
RZ Lyrae	39.9	+32 42	9.9—11.2	0 12.3	4	12;	22	21;	4	4;	22	14
RT Scuti	18 44.1	−10 30	9.1— 9.7	0 11.9	6	2;	23	22;	4	20;	16	17
κ Pavonis	18 46.6	−67 22	3.8— 5.2	9 02.2	5	8;	23	13;	1	15;	19	19
U Aquilae	19 24.0	− 7 15	6.2— 6.9	7 00.6	6	2;	20	3;	3	4;	17	5
XZ Cygni	30.4	+56 10	8.6— 9.3	0 11.2	7	7;	21	7;	4	7;	18	7
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	1	1;	17	0;	1	23;	17	22
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	7	13;	22	22;	7	7;	22	16
η Aquilae	47.4	+ 0 45	3.7— 4.5	7 04.2	4	3;	18	12;	1	20;	23	9
S Sagittae	51.5	+16 22	5.6— 6.4	8 09.2	7	9;	24	3;	9	22;	26	16
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	1	12;	14	2;	2	1;	21	0
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3	14	18;	31	3;			16	12
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	1	15;	19	9;	1	16;	14	23
WY Cygni	52.3	+30 03	9.6—10.4	0 13.5	5	8;	18	19;	1	6;	21	11
RV Capric.	55.9	−15 37	9.2—10.1	0 10.7	5	5;	18	15;	1	2;	14	12
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4	1	6;	30	17;	14	10;	29	4
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	6	16;	22	9;	7	3;	22	20
SW Aquarii	10.2	− 0 20	9.9—10.8	0 11.0	6	9;	20	3;	2	22;	23	14
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	1	9;	15	23;	4	10;	19	0
Y Lacertae	22 05.2	+50 33	9.1— 9.6	4 07.8	7	19;	25	2;	2	18;	20	1
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	6	5;	16	22;	2	1;	18	3
Z Lacertae	36.9	+56 18	8.2— 9.0	10 21.1	5	2;	26	20;	6	17;	28	12
RR Lacertae	37.5	+55 55	8.5— 9.2	6 10.1	1	11;	20	17;	2	13;	21	20
V Lacertae	22 44.5	+55 48	8.2— 8.9	4 23.6	3	19;	18	18;	2	17;	17	16
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	2	12;	18	20;	4	4;	20	11

Minima of Variable Stars of Short Period.

[Calculated by Elva Utzinger at Goodsell Observatory.]

Given to the nearest hour in Greenwich mean time; to obtain Eastern Standard time subtract 5h; Central Standard 6h; etc.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915							
					July				Aug.			
	h m	° ′		d h	d	h	d	h	d	h	d	h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8			15	19;			19	17
RT Sculptor.	31.5	−26 13	9.6—10.5	0 12.3	2	0;	17	8;	1	16;	17	1
UU Androm.	38.5	+30 24	10.7—11.9	1 11.7	2	21;	17	18;	1	15;	23	22
U Cephei	0 53.4	+81 20	7.0— 9.0	2 11.8	4	19;	19	18;	3	17;	18	16
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	7	2;	19	7;	6	16;	18	21
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	4	12;	18	18;	2	1;	16	8
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	1	18;	15	11;	5	1;	18	19
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	6	9;	20	18;	4	2;	18	10
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	6	18;	24	8;	2	2;	19	16
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	1	11;	17	8;	2	5;	18	3
RX Cassiop.	58.8	+67 11	8.6— 9.1	32 07.6			31	9				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	2	14;	19	19;	6	0;	17	11
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	3	14;	24	0;	6	14;	20	4
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	5	13;	21	8;	6	4;	21	23
RW Tauri	3 57.8	+27 51	7.1—<11	2 18.5	2	17;	19	7;	4	22;	21	13
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3	0;	18	19;	3	13;	19	8
RW Persei	13.3	+42 04	8.8—11.0	15 04.8	12	6;	25	11;	7	15;	20	20
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	3	10;	22	8;	10	5;	29	2
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1	1	4;	26	1;	7	11;	19	21
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	6	4;	19	12;	1	20;	15	4
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	1	17;	18	2;	3	11;	19	20
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	4	17;	16	18;	3	20;	15	21
SU Tauri	45.8	+28 05	9.4—11.0	2 04.0	6	13;	23	21;	1	13;	18	21
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	10	23;	31	18;	11	4;	21	14
SV Gemin.	54.6	+24 28	9.8—<11	4 00.2	3	0;	19	0;	4	1;	20	2
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	4	22;	16	9;	2	13;	19	18
U Columbae	6 11.2	−33 03	9.2—10.0	2 19.2	6	10;	17	15;	3	10;	20	5
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	6	6;	22	15;	8	1;	24	11
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	5	15;	20	21;	5	3;	20	9
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0	1	6;	25	16;	6	21;	31	7
RU Monoc.	6 49.4	− 7 28	9.8—10.5	0 21.5	6	4;	20	13;	4	21;	19	5
R Can. Maj.	7 14.9	−16 12	5.8— 6.4	1 03.3	4	10;	22	14;	9	18;	27	22
RY Gemin.	21.7	+15 52	8.9—<10	9 07.2	5	14;	24	4;	2	11;	21	2
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	10	13;	30	9;	9	7;	29	3
TX Gemin.	30.3	+17 8	10.0—11.9	2 19.2	1	0;	17	20;	3	15;	20	10
RR Puppis	43.5	−41 08	9.4—10.7	6 10.3	1	9;	14	6;	2	13;	21	20
V Puppis	7 55.4	−48 58	4.1— 4.8	1 10.9	7	9;	21	23;	5	12;	20	1
X Carinae	8 29.1	−58 53	7.9— 8.7	0 13.0	1	14;	17	20;	3	2;	19	7
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	2	3;	21	3;	9	2;	28	1
RX Hydrae	9 0.8	− 7 52	9.1—10.5	2 6.8	2	23;	21	6;	8	12;	26	18
S Antliae	27.9	−28 11	6.7— 7.3	0 07.8	1	13;	21	0;	9	11;	22	10
S Velorum	29.4	−44 46	7.8— 9.3	5 22.4	2	19;	20	14;	7	9;	25	5
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	5	23;	22	20;	8	16;	25	13
RR Velorum	10 17.8	−41 36	10.0—10.9	1 20.5	7	13;	26	2;	4	8;	22	21
SS Carinae	10 54.2	−61 23	12.2—12.8	3 07.2	3	19;	23	14;	5	19;	19	0
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	5	5;	22	19;	9	10;	27	0
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	1	5;	15	21;	6	21;	21	12
Z Draconis	11 39.8	+72 49	9.9—13.6	1 08.6	3	16;	24	1;	13	9;	26	23
RZ Centauri	12 55.6	−64 05	8.5— 8.9	1 21.0	2	15;	17	16;	1	16;	24	4
SS Centauri	13 07.2	−63 37	8.8—10.4	2 11.5	4	14;	19	11;	3	8;	18	5
δ Librae	14 55.6	− 8 07	4.8— 6.2	2 07.9	1	22;	15	21;	5	20;	19	19
U Coronae	15 14.1	+32 01	7.6— 8.7	3 10.9	4	12;	18	7;	1	3;	21	20
TW Draconis	32.4	+64 14	7.3— 8.9	2 19.4	4	20;	20	20;	6	17;	23	13

Minima of Variable Stars of Short Period—Continued.

Star	R. A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich mean times of minima in 1915							
					July				Aug.			
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SS Librae	15 43.4	−15 14	9.3—11.5	0 18.4	1 8;	24 8;	16 7;	31 14				
SW Ophiuchi	16 11.1	− 6 44	9.2—10.0	2 10.7	1 14;	16 6;	7 7;	21 23				
SX Ophiuchi	12.6	− 6 25	10.5—11.2	2 01.5	2 8;	18 20;	4 9;	20 21				
R Arae	31.1	−56 48	6.8— 7.9	4 10.2	1 14;	19 7;	6 0;	23 16				
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	6 6;	27 0;	7 2;	27 20				
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	6 23;	20 13;	3 4;	16 18				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	7 23;	24 18;	2 3;	18 22				
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	2 12;	20 23;	2 7;	20 18				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	4 5;	18 15;	2 1;	23 16				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	3 19;	18 13;	2 7;	24 10				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	8 17;	25 2;	10 10;	26 19				
TX Scorpii	48.6	−34 13	7.5— 8.2	0 22.6	1 16;	16 18;	8 9;	23 11				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	4 10;	19 21;	4 9;	19 21				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	5 14;	21 13;	6 12;	22 12				
WX Sagittae	53.6	−17 24	9.2—10.8	2 03.1	1 4;	18 5;	4 6;	21 7				
WY Sagittae	17 54.9	−23 1	9.5—10.6	4 16.0	6 19;	23 12;	13 4;	31 20				
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	10 1;	30 17;	10 1;	30 18				
RS Sagittarii	11.0	−34 08	5.9— 6.3	2 10.0	4 2;	18 14;	4 2;	16 14				
V Serpentis	11.1	−15 34	9.5—11.1	3 10.9	1 20;	15 16;	5 9;	19 4				
RZ Scuti	21.1	− 9 15	7.4— 8.3	15 03.2	4 12;	19 16;	3 19;	18 22				
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	3 4;	19 16;	5 5;	21 18				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	5 20;	23 15;	10 10;	28 5				
SX Sagittarii	39.7	−30 36	8.7— 9.8	2 01.8	2 15;	19 5;	4 20;	21 11				
RR Draconis	40.8	+62 34	9.3—13	2 19.9	8 6;	25 6;	11 6;	28 5				
RS Scuti	43.7	−10 21	9.3—10.3	0 15.9	6 21;	20 4;	2 11;	15 18				
β Lyrae	46.4	+33 15	3.4— 4.1	12 21.8	10 3;	23 1;	4 22;	30 18				
U Scuti	18 48.9	−12 44	9.1— 9.6	0 22.9	5 8;	24 11;	3 0;	22 2				
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	5 20;	21 0;	5 3;	20 7				
RV Lyrae	12.5	+32 15	11. —12.8	3 14.4	3 10;	17 19;	1 5;	15 14				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	7 22;	25 20;	3 19;	21 17				
U Sagittae	14.4	+19 26	6.5— 9.0	3 09.1	4 10;	24 17;	7 6;	20 18				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	2 8;	17 1;	8 4;	22 21				
TT Lyrae	24.3	+41 30	9.3—11.6	5 05.8	3 5;	18 22;	3 16;	19 9				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	5 20;	18 21;	7 11;	20 12				
SY Cygni	19 42.7	+32 28	10 —12	6 00.2	2 3;	14 4;	1 4;	19 5				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	4 21;	24 19;	7 1;	20 8				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	7 3;	25 10;	3 13;	21 20				
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	2 19;	19 16;	5 13;	22 9				
RW Capric.	12.2	−17 59	8.8—10.6	3 09.4	2 16;	16 5;	5 14;	19 3				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	1 12;	15 8;	5 1;	18 20				
V Vulpec.	32.3	+26 15	8.2—9.8	37 19.0		2 16		9 11				
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	3 20;	23 1;	11 7;	30 12				
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	6 10;	24 20;	12 5;	30 15				
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	5 11;	20 11;	4 10;	19 10				
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	2 20;	20 9;	6 21;	18 14				
RR Vulpec.	20 50.5	+27 32	9.6—11.0	5 01.2	2 6;	22 10;	11 15;	31 20				
VV Cygni	21 02.3	+45 23	12.1—13.8	1 11.4	3 13;	18 8;	2 2;	16 21				
AE Cygni	09.0	+30 20	10.8—11.4	0 23.3	7 2;	26 11;	5 3;	24 13				
RY Aquarii	14.8	−11 14	8.8—10.4	1 23.2	5 15;	21 8;	6 2;	21 20				
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3		10 19;		11 2				
RT Lacertae	21 57.4	+43 24	9.1—10.5	5 01.7	3 12;	23 19;	13 2;	23 5				
RW Lacertae	22 40.6	+49 08	10.2—11.2	5 04.4	5 16;	21 5;	5 19;	21 8				
X Lacertae	22 45.0	+55 54	8.2— 8.6	5 10.6	4 17;	21 1;	6 9;	17 6				
TT Androm.	23 08.7	+45 36	11.3—12.6	2 18.3	3 23;	20 13;	6 4;	22 18				
Y Piscium	29.3	+ 7 22	9.0—12.0	3 18.4	7 11;	22 13;	6 14;	21 16				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	3 1;	19 12;	5 0;	21 12				

Results of Variable Star Observations made at West Collingswood, N. J. by H. C. Bancroft, Jr.

Variable	Designation	Phase	Date	Magnitude	Number of Observations	First Observation		Last Observation	
						Date	Mag.	Date	Mag.
Y Cephei	003179	Max.	1914 Feb. 10	9.5	15	1914 Jan. 22	11.0	1914 Apr. 4	11.8
U Arietis	030514	Max.	1914 Mar. 5	8.5	16	1913 Dec. 3	13.7	1914 Mar. 24	9.0
R Persei	032335	Max.	1914 Jan. 18	8.4	18	1913 Oct. 31	12.9	1914 Mar. 24	10.85
RX Tauri	043208	Max.	1914 Feb. 13	9.0	15	1913 Dec. 3	12.5	1914 Apr. 10	10.45
X Aurigae	060450	Max.	1914 Mar. 10	8.45	15	1913 Dec. 30	13.2	1914 Apr. 27	12.0
V Monoc.	*061702*	Max.	1914 Mar. 5	7.0	16	1913 Dec. 3	10.5	1914 Apr. 18	8.5
S Lyncis	063558	Max.	1914 May 6	10.0	16	1914 Mar. 23	12.6	1914 June 11	10.8
R Urs. Maj.	103769	Min.	1914 Jan. 29	13.2	43	1913 Oct. 4	10.0	1914 Sept. 16	12.2
		Max.	1914 May 1	7.8					
T Virginis	*120905*	Max.	1914 Apr. 17	9.5	12	1914 Mar. 20	11.2	1914 June 20	11.3
T Urs. Maj.	123160	Min.	1914 Jan. 17	12.9	33	1913 Nov. 3	10.1	1914 Sept. 8	12.8
		Max.	1914 Apr. 25	7.6					
RR Urs. Maj.	123459	Max.	1914 July 5	8.3	19	1914 Apr. 23	13.4	1914 Sept. 16	12.4
S Urs. Maj.	123961	Max.	1914 Mar. 14	7.6	43	1914 Jan. 5	10.1	1914 Oct. 10	7.9
		Min.	1914 July 17	11.45					
R Can. Ven.	134440	Max.	1914 Apr. 6	6.8	28	1913 Oct. 5	11.9	1914 Sept. 26	11.9
Z Bootis	140113	Max.	1914 June 11	9.8	8	1914 May 16	12.2	1914 July 28	11.8
S Bootis	141954	Max.	1914 Mar. 29	8.5	30	1913 Dec. 28	11.9	1914 Oct. 10	11.2
		Min.	1914 Aug. 15	11.95					
RS Virginis	142205	Max.	1914 July 7	7.9	10	1914 Apr. 27	12.5	1914 Sept. 9	10.5
V Bootis	142539	Max.	1914 June 8	7.4	25	1914 Jan. 27	10.7	1914 Sept. 30	9.9
R Camelop.	142584	Max.	1914 Mar. 9	8.3	9	1913 Dec. 28	9.5	1914 May 30	11.2
R Bootis	143227	Min.	1914 Mar. 17	12.2	20	1914 Mar. 15	9.2	1914 Oct. 10	9.15
		Max.	1914 Sept. 2	7.4					
X Cor. Bor.	154536	Max.	1914 July 11	8.9	15	1914 Apr. 23	12.4	1914 Sept. 26	12.75
R Herculis	160118	Max.	1914 May 29	8.0	10	1914 Apr. 23	9.0	1914 Aug. 15	11.3
V Serpentis	160210	Max.	1914 Mar. 16	7.8	7	1914 Feb. 1	11.0	1914 June 15	12.5
RU Herculis	160625	Max.	1913 Dec. 6	7.1	26	1913 May 7	13.8	1914 July 19	13.2
W Cor. Bor.	161138	Max.	1914 Aug. 25	8.3	15	1914 June 15	12.0	1914 Oct. 10	10.4
SS Herculis	162807	Max.	1914 May 21	8.7	20	1914 Apr. 23	11.1	1914 Oct. 10	10.73
		Min.	1914 July 18	12.4					
		Max.	1914 Sept. 15	8.6					
R Draconis	163266	Min.	1913 Dec. 17	12.3	39	1913 Oct. 10	10.5	1914 Oct. 10	10.35
		Max.	1914 Apr. 6	7.6					
		Min.	1914 Aug. 11	12.3					
S Herculis	164715	Min.	1914 Mar. 8	12.3	23	1913 Nov. 17	8.5	1914 Oct. 10	9.5
		Max.	1914 Aug. 5	7.4					
RV Herculis	165631	Max.	1914 June 28	10.6	9	1914 May 17	13.4	1914 Aug. 15	12.6
R Ophiuchi	*170215*	Max.	1914 Aug. 27	7.6	15	1914 May 17	12.0	1914 Oct. 10	8.9
RS Herculis	171723	Max.	1914 Aug. 18	8.0	13	1914 May 17	12.8	1914 Oct. 10	10.1
W Draconis	180565	Max.	1914 July 27	9.6	14	1914 May 31	11.9	1914 Oct. 10	11.9
W Lyrae	181136	Max.	1914 July 5	7.7	17	1914 Apr. 27	12.2	1914 Oct. 10	12.4
RT Aquilæ	193311	Max.	1914 Aug. 6	8.0	13	1914 May 31	13.0	1914 Sept. 30	9.8
RT Cygni	194048	Min.	1914 July 12	12.0	13	1914 Apr. 24	8.2	1914 Sept. 8	8.0
TU Cygni	194348	Max.	1914 Sept. 3	9.7	10	1914 July 29	12.4	1914 Sept. 30	10.4
ST Cygni	202954	Max.	1913 Dec. 23	10.0	17	1913 Aug. 25	13.0	1914 Feb. 1	11.5
V Cassiop.	230759	Max.	1914 July 31	7.9	13	1914 May 31	10.3	1914 Sept. 28	10.5

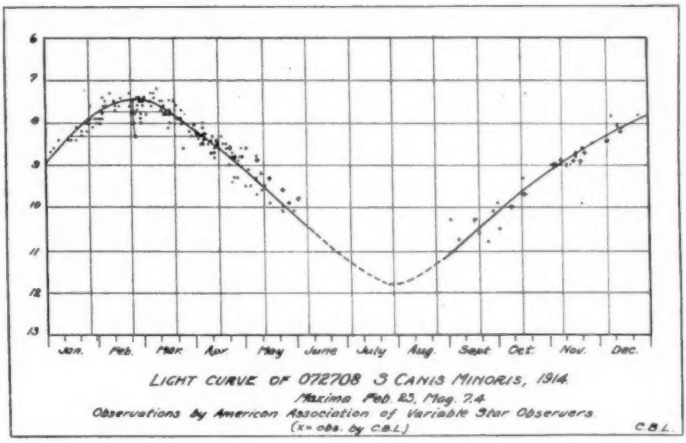
Total number of observations —680

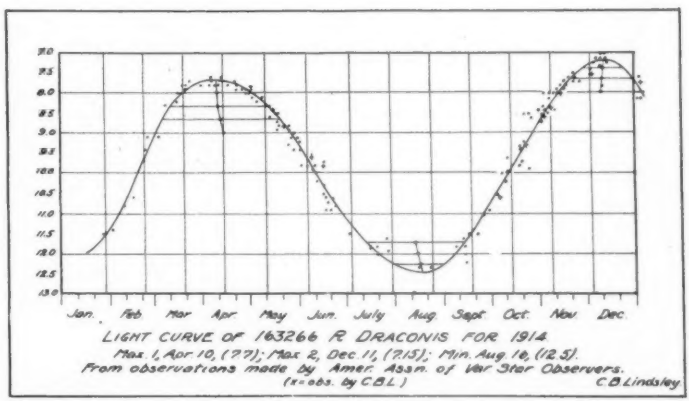
Notes. The Variable SS Herculis is especially interesting. The time between the two maxima as indicated in the table is 117 days. *Harvard Annals* give a period of 100 days range 9.0 to <12.0. According to these observations the minimum falls exactly midway between the maxima.

A curve was plotted to obtain each phase given in the table.

Instrument—5½″ refractor.

West Collingswood, N. J.
April 10, 1915.

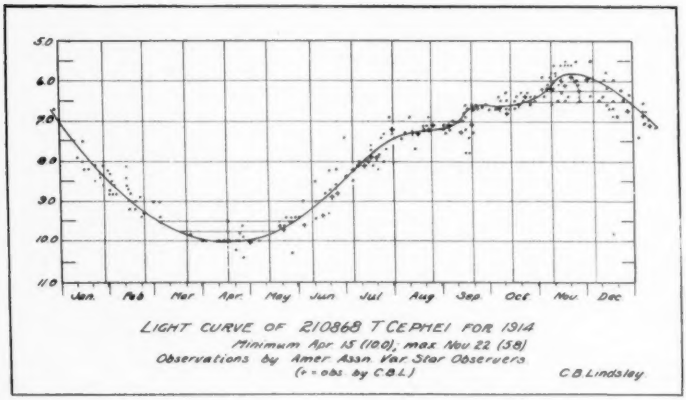


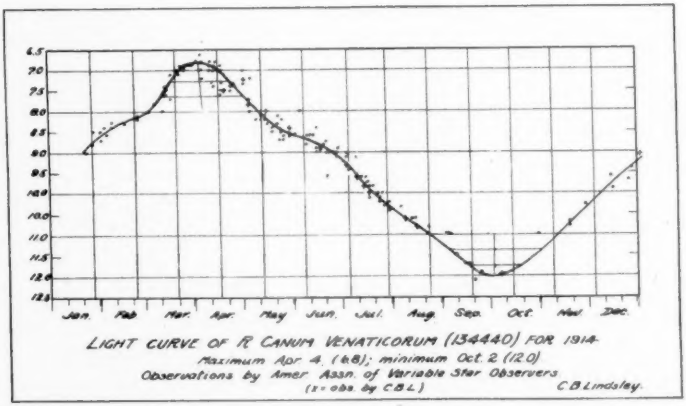


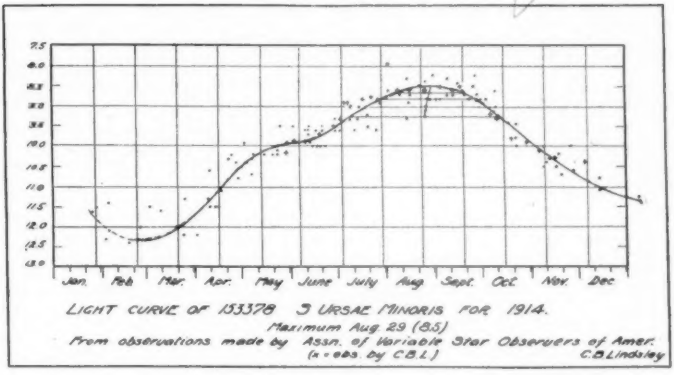
Elements of RS Canum Venaticorum.—The variability of this star, which is the same as BD 36° 2344, was discovered by L. Ceraski and announced in *A. N.* 4719. From observations accumulated since June 1914, Cuno Hofmeister has concluded that this star is of the Algol type, the change in the light of the star extending over a period of about 11 hours. The elements for this variable are given as:—Min. = 2420297.571 J. D. + $4^d.796960$ E. Minima are predicted for the rest of this year as follows:

	d	h		d	h
July	2	7.9	Oct.	1	11.3
Aug.	0	2.6	Nov.	4	1.2
Sept.	2	16.5	Dec.	2	19.9

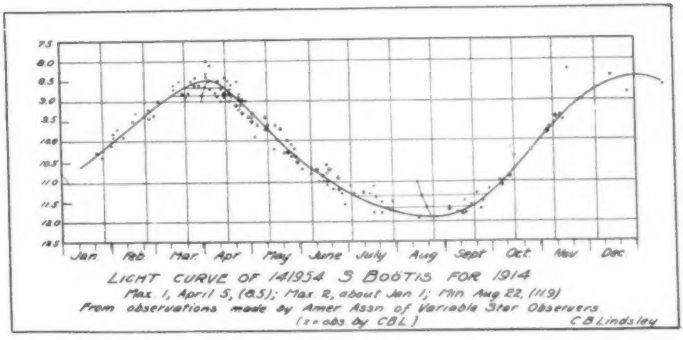
Its light ranges from $7^m.85$ to $8^m.93$.



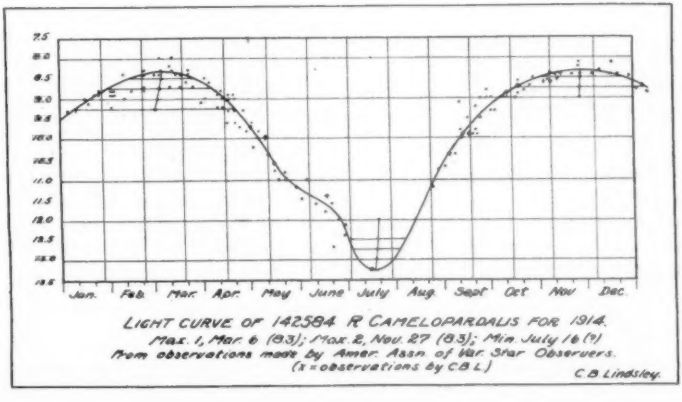




LIGHT CURVE OF 133378 S URSAE MINORIS FOR 1914.
Maximum Aug. 29 (8.5)
From observations made by Assn. of Variable Star Observers of Amer.
(x = obs. by C.B.L.)
C.B. Lindsley



LIGHT CURVE OF 141954 S BOÖTIS FOR 1914
Max. 1, April 5, (8.5); Max. 2, about Jan. 1; Min. Aug. 22, (11.9)
From observations made by Amer. Assn. of Variable Star Observers.
(x = obs. by C.B.L.)
C.B. Lindsley



LIGHT CURVE OF 142584 R CAMELOPARDALIS FOR 1914.
Max. 1, Mar. 6 (8.3); Max. 2, Nov. 27 (8.3); Min. July 16 (?)
From observations made by Amer. Assn. of Var. Star Observers.
(x = observations by C.B.L.)
C.B. Lindsley.

COMET AND ASTEROID NOTES.

Comet 1915 *a* (Mellish).—A telegram from the Yerkes Observatory announces that Professor Barnard found two companions to Mellish's comet. On May 12 at $19^h\ 36^m$ the brighter companion was in position angle, 285° distance 28″ The other was faint and in an intermediate position on the same line. At Goodsell Observatory on May 18 at $21^h\ 05^m$ G.M.T. one companion was observed in position angle 289°, distance 36″.

Comet 1915 *a* (Mellish).—The following telegram from Professor Percival Lowell, director of the Lowell Observatory, Flagstaff, Arizona, was received on the morning of May 24.

"Comet has disrupted. Observations and photographs of Mellish comet at the Lowell Observatory by Mr. Lampland and Mr. E. C. Slipher, prove that the smaller nuclei, four in all, accompanying the comet, are slowly receding from it at the rate of about four seconds of arc a day, which indicates that the comet has broken up. The innermost attendant shows a stellar nucleus with the usual envelopes and the outermost seems itself to be disintegrating. What forces or accidents of approach have occasioned the disruption is not yet ascertained.

"It will be remembered that the spectrum of this comet was found here sometime since to possess peculiarity."

Elements of Comet 1915 *a* (Mellish).—I am sending you my latest elements of Mellish's Comet (1915 *a*), based upon only three places. The integral between the first and last place is 58 days. The eccentricity comes out slightly greater than unity. The value of x' is $-\ 0.0000164$ (bottom of page 254 Watson's Theoretical Astronomy,) showing that the orbit comes out practically parabolic, but theoretically hyperbolic. The formulae all check.

ELEMENTS OF COMET *a* 1915 (MELLISH).

$T = 1915$ July 18.57390 G. M. T.
$\omega = 247°\ 36'\ 34''.02$
$\pi = 319\ \ 56\ \ 21\ .80$
$\Omega = \ 72\ \ 19\ \ 47\ .78$
$i = \ 54\ \ 43\ \ 51\ .96$
$e = 1.0012212$
$\log q = 0.0076607$

CONSTANTS FOR THE EQUATOR 1915.0.

$x = r\ [9.7982014] \sin (151°\ \ 6'\ 50''.64 + u)$
$y = r\ [9.9490903] \sin (100\ 38\ 10.04 + u)$
$z = r\ [9.9553568] \sin (\ 24\ 51\ \ 6.17 + u)$

F. E. SEAGRAVE.

Ephemeris of Winnecke's Periodic Comet.—In the *Astronomische Nachrichten* No. 4787 is given an ephemeris of Winnecke's periodic comet for this summer calculated by Dr. E. Waage, of the observatory at Graz, Germany. The elements, computed from seven normal places based upon the observations made during the apparition of 1909-10, when brought up to 1915 are as follows:

Osculation epoch 1915 Sept. 3.0 Berlin mean time.

$T = 1915$ Sept. 1.04736
$\omega = 172°\ 19'\ 49''.1$
$\Omega = \ 99\ \ 23\ \ 04\ .9$
$i = \ 18\ \ 17\ \ 46\ .3$
$\log q = 9.987507$
$e = 0.701439$

$$x = [9.978101]\ r \sin (v + 2^\circ\ 12'\ 18.4'')$$
$$y = [9.974822]\ r \sin (v + 278^\circ\ 45'\ 48.2'')$$
$$z = [9.656310]\ r \sin (v + 232^\circ\ 21'\ 45.1'')$$

The portion of the ephemeris for June and July is given herewith.

EPHEMERIS OF WINNECKE'S COMET.

1915	App. α	App. δ	log r	log Δ
	h m s	° ′ ″		
June 3	10 21 11.90	+30 54 43.4	0.191397	0.171169
4	22 37.04	40 29.1		
5	24 3.89	26 2.2		
6	25 32.44	30 11 22.6		
7	27 2.67	29 50 30.2	0.180843	0.170064
8	28 34.56	41 24.8		
9	30 8.11	26 0.2		
10	31 43.29	29 10 33.3		
11	33 20.09	28 54 49.0	0.170078	0.168441
12	34 58.49	38 50.0		
13	36 38.47	22 37.2		
14	38 20.01	28 6 10.5		
15	40 3.10	27 49 29.6	0.159120	0.166280
16	41 47.73	32 34.5		
17	43 33.87	27 15 24.9		
18	45 21.51	26 58 0.7		
19	47 10.63	40 21.5	0.147978	0.163562
20	49 1.22	22 27.3		
21	50 53.27	26 4 17.9		
22	52 40.76	25 45 53.0		
23	54 41.68	27 12.4	0.136678	0.160279
24	56 38.02	25 8 16.0		
25	10 58 35.77	24 49 3.4		
26	11 0 34.92	29 34.4		
27	2 35.45	24 9 48.7	0.125246	0.156430
28	4 37.36	23 49 46.0		
29	6 40.64	29 26.1		
30	8 45.29	23 8 48.7		
July 1	11 10 51.31	22 47 53.5	0.113718	0.152016
2	12 58.69	22 26 40.2		
3	15 7.43	5 8.4		
4	17 17.54	21 43 18.0		
5	19 29.01	21 21 8.6	0.102137	0.147038
6	21 41.83	20 58 39.9		
7	23 56.01	35 51.7		
8	26 11.55	20 12 43.7		
9	28 28.45	19 49 15.7	0.090559	0.141506
10	30 46.70	25 27.3		
11	33 6.30	19 1 18.4		
12	35 27.26	18 36 48.6		
13	37 49.57	18 11 57.8	0.079052	0.135407
14	40 13.23	17 46 45.7		
15	42 38.23	17 21 11.9		
16	45 4.58	16 55 16.3		
17	47 32.29	28 58.5	0.067696	0.128771
18	50 1.35	16 2 18.4		
19	52 31.76	15 35 15.7		
20	55 3.53	15 7 50.1		
21	11 57 36.65	14 40 1.4	0.056583	0.121615
22	12 0 11.13	14 11 49.3		
23	2 46.98	13 43 13.6		
24	5 24.21	13 14 14.1		
25	8 2.81	12 44 50.5	0.045822	0.113971
26	10 42.80	12 15 2.7		
27	13 24.20	11 44 50.3		
28	16 7.02	11 14 13.1		
29	12 18 51.27	+10 43 11.0	0.035537	0.105888

Rediscovery of Winnecke's Comet 1915 *b*.—According to the *Astronomische Nachrichten* 4798, Winnecke's periodic comet was photographed by Mr. H. Thiele at the Hamburg Observatory on April 4. It is yet invisible in small telescopes, being of magnitude 16. Its position determined from the photograph was

1915 April 4 $10^h\ 48^m.6$ Gr. M. T. $\alpha = 10^h\ 01^m\ 17^s$ $\delta = +38^\circ\ 54'.6$.

The correction to the ephemeris on page 383 is $-1^m\ 18^s + 8'$.

Rediscovery of the Periodic Comet Tempel$_2$ (1915 *c* Delavan).—A cablegram from Dr. Felix Aguilar, of LaPlata, Argentina, to Harvard College Observatory announces the discovery of a comet by Delavan in the following position:

May 16.8696 Gr. M. T. R. A. $0^h\ 33^m\ 01^s$ Dec. $-2^\circ\ 05'\ 31''$.

This is very close to the position predicted for Tempel's periodic comet (See P. A. for April p. 310). A later position cabled from Cordoba, Argentina makes it certain that the object is Tempel's comet. It is visible in a small telescope but is not in favorable position for northern observers. The following are all the observations which have come to hand:

Gr. M. T.	α	δ	Observer	Place
May 16.8696	0 33 01.0	−2 05 31	Delavan	LaPlata
19.8843	0 42 13.2	−1 29 24	Miss Glancy	Cordoba

Definitive Elements of Comet 1909 I (Borrelly-Daniel.)—In the Publications of the Royal Observatory di Brera in Milan, Mr. Luigi Gabba gives definitive elements of the comet 1909 I, computed from seven normal places based upon all available published observations from June 16 to August 19. The parabolic elements are as follows:

$T = 1909$ June 5.32998 Berlin mean time.
$\omega = 5^\circ\ 04'\ 54''.0$
$\Omega = 305\ 41\ 03\ .0$ } 1909.0
$i = 52\ 05\ 19\ .2$
$\log q = 9.926081$

Approximate Ephemeris of Comet 1915 *a* (Mellish.)—The following ephemeris of Mellish's comet, given by E. Stromgren in *A. N.* 4792 shows that the comet, after going down near the south pole of the sky, will slowly return northward and may be visible again to northern observers next winter.

		α	δ	$\log r$	$\log \Delta$	Mag.
		h	°			
1915	Mar. 25	17.9	− 1	0.332	0.260	8.8
	Apr. 25	18.5	− 7	0.258	0.054	7.4
	May 25	19.1	−31	0.178	9.771	5.6
	June 25	3.8	−84	0.106	9.708	5.4
	July 25	6.7	−58	0.075	9,913	5.8
	Aug. 25	6.6	−48	0.109	0.019	6.5
	Sept. 25	6.1	−47	0.184	0.062	7,1
	Oct. 25	4.8	−42	0.262	0.077	7.5
	Nov. 25	3.5	−29	0.336	0.146	8 3
	Dec. 25	2.9	−14	0.398	0.273	9.2
1916	Jan. 25	3.0	− 2	0.454	0.410	10.2
	Feb. 25	3.3	+ 6	0.503	0.524	11.1

NOTES FOR OBSERVERS.

VARIABLE STAR OBSERVATIONS Apr.-May 1915.

001755
T Cassiop.

Mo.	Day	Est.	Obs.
3	22	8.7	R

004958
W Cassiop.

Mo.	Day	Est.	Obs.
4	2	9.1	Bb
	7	9.2	Bb

011272
S Cassiop.

Mo.	Day	Est.	Obs.
3	22	9.3	R
4	2	8.0	Bb
	6	9.0	Ly
	7	8.1	Bb
	8	9.2	R
	11	9.1	Ly
	11	9.1	R
	15	9.2	R

015354
U Persei

Mo.	Day	Est.	Obs.
3	22	8.8	R
4	3	8.2	V
	8	8.8	R

021024
R Arietis

Mo.	Day	Est.	Obs.
3	22	9.2	R

021403
o Ceti

Mo.	Day	Est.	Obs.
4	2	5.0	Bb

021558
S Persei

Mo.	Day	Est.	Obs.
3	22	10.1	R
4	2	9.9	Bb
	6	9.9	Ly
	8	10.1	R
	11	9.9	R
	15	9.8	R

024356
W Persei

Mo.	Day	Est.	Obs.
3	22	10.3	R
4	6	9.8	Ly
	8	10.4	R
	11	10.4	R
	15	10.2	R

032043
Y Persei

Mo.	Day	Est.	Obs.
3	22	9.8	R
4	2	9.9	Bb
	6	9.8	Ly
	8	9.7	R
	9	9.9	Bb
	11	9.5	R
	15	9.7	R
	20	10.2	Bb

032335
R Persei

Mo.	Day	Est.	Obs.
3	22	8.6	R
4	8	8.9	R
	11	9.1	R
	13	9.6	S
	15	9.0	R

033362
U Camelop.

Mo.	Day	Est.	Obs.
3	22	8.5	R
4	8	8.4	R
	11	8.5	R
	15	8.5	B

035915
V Eridani

Mo.	Day	Est.	Obs.
3	22	8.9	R

042215
W Tauri

Mo.	Day	Est.	Obs.
4	2	10.6	B
	2	10.5	Bb
	7	10.3	Bb
	7	10.6	Ly
	13	10.1	Y
	13	10.3	Ly
	14	10.1	B
	20	10.0	Bb

042309
S Tauri

Mo.	Day	Est.	Obs.
4	2	13.5	B
	14	12.4	B

043208
RX Tauri

Mo.	Day	Est.	Obs.
4	2	11.7	Bb
	2	12.4	B
	7	11.8	Bb
	12	12.7	B
	20	12.0	Bb

043274
X Camelop.

Mo.	Day	Est.	Obs.
3	22	11.1	R
4	8	11.5	Hr
	20	12.5	B

044617
V Tauri

Mo.	Day	Est.	Obs.
4	2	13.3	B
	14	13.0	B

045514
R Leporis

Mo.	Day	Est.	Obs.
3	22	9.6	R

050003
V Orionis

Mo.	Day	Est.	Obs.
4	14	9.3	B

050953
R Aurigae

Mo.	Day	Est.	Obs.
3	22	8.6	R
4	4	8.2	Ly
	5	8.5	Bu
	6	9.9	M
	8	8.4	R
	11	8.3	R
	14	7.8	Ly
	15	8.2	R
	18	8.3	R
	19	7.9	B
	19	8.4	R
	19	8.0	Bu

052034
S Aurigae

Mo.	Day	Est.	Obs.
4	5	8.6	Bu
	15	9.4	M
	19	8.6	B
	23	9.8	M

054920
U Orionis

Mo.	Day	Est.	Obs.
4	5	9.0	Bu
	12	8.6	S
	15	8.8	M
	15	8.8	Ly

054974
V Camelop.

Mo.	Day	Est.	Obs.
4	19	9.9	B
	19	9.8	Bu

055353
Z Aurigae

Mo.	Day	Est.	Obs.
4	4	9.4	M
	7	9.7	Y
	15	9.6	M
	19	9.7	Bu

060124
S Leporis

Mo.	Day	Est.	Obs.
3	22	6.5	R
4	8	6.1	R
	11	6.2	R
	15	6.5	R

061647
V Aurigae

Mo.	Day	Est.	Obs.
4	7	10.9	Y
	19	10.2	B
	19	10.0	Bu

063159
S Leonis

Mo.	Day	Est.	Obs.
4	21	13.1	B

061407
T Monoc.

Mo.	Day	Est.	Obs.
4	2	6.8	Bu
	5	6.5	Bu
	8	6.2	Bu
	11	6.0	Bu
	13	6.2	Bu
	15	6.4	Bu
	17	6.5	Bu
	19	6.6	Bu
	21	6.6	Bu
	25	6.8	Bu

063558
S Lyncis

Mo.	Day	Est.	Obs.
4	5	10.7	Bu
	8	10.5	Hr
	13	11.0	O
	20	10.7	B

064030
X Gemin.

Mo.	Day	Est.	Obs.
4	13	11.0	O
	13	11.3	Y

064932
Nova Gemin. II

Mo.	Day	Est.	Obs.
4	2	12.1	Bb
	7	12.0	Bb
	20	12.3	Bb
	27	12.2	Bb

065111
Y Monoc.

Mo.	Day	Est.	Obs.
4	3	9.4	V
	5	9.2	Bu
	12	9.5	Y
	16	9.2	V

065208
X Monoc.

Mo.	Day	Est.	Obs.
3	22	9.8	R
4	8	9.5	R
	11	9.4	R
	15	9.6	R
	19	9.3	R

065355
R Lyncis

Mo.	Day	Est.	Obs.
3	22	8.7	R
4	5	9.0	Bu
	8	9.2	R
	11	9.2	R
	12	9.0	E
	15	9.4	R
	18	9.5	R
	19	9.5	R
	19	9.7	Bu

065820
ξ Gemin.

Mo.	Day	Est.	Obs.
3	21	3.8	R
	22	3.7	R
4	1	3.7	R
	3	3.8	R
	8	3.8	R
	11	3.8	R
	13	3.7	R
	15	4.1	R
	18	4.1	R
	19	3.8	R

070122
TW Gemin.

Mo.	Day	Est.	Obs.
4	14	8.2	Ly

070122a
R Gemin.

Mo.	Day	Est.	Obs.
4	8	12.3	B
	12	12.5	B
	12	12.4	Y

070310
R Can. Min.

Mo.	Day	Est.	Obs.
4	5	9.7	Bu
	18	9.3	O
	19	9.2	Bn
	20	9.1	B

072708
S Can. Min.

Mo.	Day	Est.	Obs.
3	22	8.7	R
4	2	9.2	Bb
	4	9.5	Ly
	5	9.6	Bu
	7	9.3	Bb
	7	10.0	Ly
	8	9.4	R
	8	10.0	M
	11	9.2	R
	12	9.9	S
	13	9.7	Pi
	13	10.5	O
	14	10.2	Ly
	15	9.3	R
	18	10.3	O
	19	10.1	Bu
	19	9.9	R
	20	10.1	B
	20	9.5	Bb
	27	9.5	Bb

072811
T Can. Min.

Mo.	Day	Est.	Obs.
4	12	12.8	Y
	21	12.6	B

073508
U Can. Min.

Mo.	Day	Est.	Obs.
4	5	10.8	Bu
	8	10.0	Hr
	12	11.2	Y
	20	11.3	B

VARIABLE STAR OBSERVATIONS Apr.-May, 1915—Continued.

073723
S Gemin.

Mo.	Day	Est.	Obs.
4	13	13.9	B

074323
T Gemin.

Mo.	Day	Est.	Obs.
3	22	10.3	R
4	7	11.3	M
	13	11.2	Y
	17	11.9	M

081112
R Cancri

Mo.	Day	Est.	Obs.
4	5	8.8	Bu
	11	8.6	R
	15	8.6	R
	18	8.6	R
	18	8.9	O
	19	8.7	R
	19	8.5	Bu

081617
V Cancri

Mo.	Day	Est.	Obs.
4	5	8.8	Bu
	11	8.8	R
	13	8.5	O
	15	8.8	R
	18	8.4	O
	18	8.7	R
	19	8.6	R
	19	8.8	Bu

081733
T Lyncis

Mo.	Day	Est.	Obs.
4	7	10.4	M
	29	11.4	M

082405
RT Hydrae

Mo.	Day	Est.	Obs.
4	6	8.4	Bu
	8	8.3	B
	12	8.3	Pi
	19	8.1	Bu

084803
S Hydrae

Mo.	Day	Est.	Obs.
3	22	8.1	R
4	4	7.7	Ly
	6	7.8	Bu
	7	7.6	Ly
	8	9.2	Hr
	8	8.0	R
	8	7.9	B
	11	8.0	R
	12	8.1	Pi
	13	7.7	O
	13	8.1	Ma
	15	8.1	Pi
	15	7.9	R
	17	8.0	Pi
	18	7.9	O
	19	7.9	R
	20	8.0	Ly
	21	8.2	Bu

085008
T Hydrae

Mo.	Day	Est.	Obs.
3	22	8.1	R
4	6	8.6	Bu
	8	8.4	R
	11	8.6	R
	15	8.5	R
	19	8.6	R
	21	8.8	Bu

085120
T Cancri

Mo.	Day	Est.	Obs.
4	6	9.3	Bu
	12	9.1	B

090425
W Cancri

Mo.	Day	Est.	Obs.
4	12	12.8	B
	13	12.8	Y

093014
X Hydrae

Mo.	Day	Est.	Obs.
4	6	9.8	Bu
	12	9.3	Pi
	13	9.3	Pi
	13	9.6	Y

093934
R Leo. Min.

Mo.	Day	Est.	Obs.
3	22	9.3	R
4	4	9.0	M
	6	9.2	Bu
	6	9.1	Ly
	7	9.0	Bb
	12	9.4	E
	14	9.3	Ly
	17	9.5	Pi
	20	9.1	Bb
	21	9.6	Bu

094211
R Leonis

Mo.	Day	Est.	Obs.
3	22	8.4	R
4	4	8.2	Mu
	4	8.5	Ly
	6	8.5	Bu
	6	8.4	M
	8	8.0	B
	10	8.6	Mu
	11	9.0	R
	12	8.0	Pi
	12	8.9	E
	12	8.8	Mu
	13	8.8	O
	13	8.8	Ma
	14	8.9	Mu
	15	9.1	R
	15	8.2	Pi
	17	8.8	Pi
	18	9.0	O
	18	8.9	R
	19	9.0	R
	20	9.1	Ly
	21	8.8	Pi
	21	9.2	Bu
	29	9.1	M

094622
Y Hydrae

Mo.	Day	Est.	Obs.
4	8	6.8	R
	11	6.9	R
	15	6.9	R
	19	6.9	R

095421
V Leonis

Mo.	Day	Est.	Obs.
4	3	9.7	V
	6	10.4	Bu
	13	10.9	O
	16	10.9	V
	18	10.9	O
	21	10.9	Bu
	29	11.4	M

103769
R Urs. Maj.

Mo.	Day	Est.	Obs.
3	22	6.8	R
4	2	8.0	Bb
	4	7.9	Ly
	6	8.0	Bu
	7	7.8	M
	7	8.2	Bb
	7	7.9	Ly
	7	7.9	M
	8	7.5	R
	11	7.6	R
	11	8.0	Ly
	12	8.2	Pi
	13	8.0	O
	13	8.3	Ma
	13	8.0	Sp
	13	8.2	S
	15	8.1	M
	15	8.0	R
	17	8.5	Ma
	17	8.5	Pi
	17	8.2	Ly
	18	8.6	O
	18	8.1	Sp
	18	7.9	R
	19	8.0	R
	20	8.2	Bb
	20	8.2	Bu
	23	8.7	M
	27	8.3	Bb
	28	8.8	M
	30	8.4	Ly

104620
V Hydrae

Mo.	Day	Est.	Obs.
4	8	7.6	Y
	12	8.3	Pi

110506
S Leonis

Mo.	Day	Est.	Obs.
4	8	12.0	Y
	29	11.8	M

120012
SU Virginis

Mo.	Day	Est.	Obs.
4	3	11.1	V
	8	11.4	Y
	13	11.5	Pi
	16	12.4	Bu

120905
T Virginis

Mo.	Day	Est.	Obs.
4	3	9.9	V
	6	10.0	Bu
	7	9.9	Sp
	13	9.7	Pi
	14	10.0	Y
	16	10.4	V
	16	10.3	B
	18	9.8	Sp
	21	10.0	Bu

121418
R Corvi

Mo.	Day	Est.	Obs.
4	2	10.5	B
	4	9.7	Ly
	7	9.4	M
	7	10.4	Sp
	14	9.1	Ly
	14	9.1	B
	14	9.6	Y
	15	9.5	R
	18	8.8	Sp
	18	8.9	R
	21	9.0	Bu
	30	8.0	Ly

122001
SS Virginis

Mo.	Day	Est.	Obs.
4	14	7.9	B
	18	7.6	O
	21	7.7	Bu

122803
Y Virginis

Mo.	Day	Est.	Obs.
4	16	13.0	B

123160
T Urs. Maj.

Mo.	Day	Est.	Obs.
3	22	10.5	R
4	4	11.4	Ly
	7	11.2	M
	7	11.6	Ly
	14	11.4	M
	14	11.7	Ly
	19	12.0	Sp
	29	11.8	M

123307
R Virginis

Mo.	Day	Est.	Obs.
4	6	7.2	Bu
	7	7.0	M
	11	7.3	Ly
	12	7.8	S
	13	7.6	Pi
	14	7.5	Ma
	16	7.5	B
	17	7.5	Ly

R Virginis

Mo.	Day	Est.	Obs.
4	18	7.6	O
	19	7.8	R
	20	7.4	Ly
	21	7.8	Bu
	21	7.6	Pi
	30	7.4	Ly

123459
RS Urs. Maj.

Mo.	Day	Est.	Obs.
4	4	9.4	M
	6	9.5	M
	6	9.8	Bu
	7	9.5	M
	8	10.2	M
	12	10.0	Pi
	14	10.3	M
	17	10.4	M
	17	9.9	Pi
	18	10.0	O
	21	10.3	Bu
	23	10.5	M

123961
S Urs. Maj.

Mo.	Day	Est.	Obs.
4	4	9.8	M
	4	9.9	Ly
	6	10.0	Bu
	7	9.7	M
	7	10.0	Ly
	11	9.9	Ly
	12	9.7	Pi
	13	9.4	O
	13	9.2	Ma
	14	9.2	M
	14	9.2	Ma
	14	9.5	Ly
	17	9.0	Ly
	17	9.0	M
	17	9.3	Ma
	17	9.1	Pi
	18	9.2	O
	19	8.5	Sp
	20	9.	Bu
	21	8.8	Ly
	23	8.9	M
	28	8.8	M
	30	8.6	Ly

124204
RU Virginis

Mo.	Day	Est.	Obs.
4	16	12.6	B

124606
U Virginis

Mo.	Day	Est.	Obs.
4	6	8.5	Bu
	11	8.8	Ly
	12	9.0	S
	14	8.9	Ly
	14	9.3	B
	17	9.1	Ly
	18	9.3	O

VARIABLE STAR OBSERVATIONS Apr.-May, 1915—Continued.

U Virginis

Mo.	Day	Est.	Obs.
4	19	9.6	R
	20	9.2	Ly
	21	9.2	Bu
	30	9.6	Ly

132706

S Virginis

Mo.	Day	Est.	Obs.
4	6	9.5	Ly
	6	9.2	Bu
	8	9.0	M
	13	9.3	Pi
	20	9.6	Ly
	21	9.4	Pi
	21	9.5	Bu
	30	9.7	Ly

134440

R Can. Ven

Mo.	Day	Est.	Obs.
3	22	8.0	
4	6	8.8	R
	6	8.6	Ly
	8	8.5	Bu
	8	8.6	M
	8	8.4	R
	11	8.9	Ly
	11	8.6	R
	12	8.6	Pi
	12	8.9	E
	13	8.8	S
	15	8.9	Pi
	15	8.7	R
	18	8.8	O
	19	8.7	R
	20	9.0	Ly
	21	8.8	Bu
	23	8.9	M
	30	9.5	Ly

140013

Z Bootis

Mo.	Day	Est.	Obs.
4	4	9.7	Y

141567

U Urs. Min.

Mo.	Day	Est.	Obs.
4	4	9.1	Ly
	6	9.3	Bu
	8	9.3	Bu
	13	9.2	S
	14	10.1	M

141954

S Bootis

Mo.	Day	Est.	Obs.
4	4	11.8	M
	12	12.0	E

142539

V Bootis

Mo.	Day	Est.	Obs.
3	22	7.9	R
4	4	8.2	M
	6	8.0	Ly
	7	8.0	Sp
	8	8.3	M
	8	8.1	R
	8	8.4	Bu
	9	8.3	Ly
	11	8.1	R
	12	8.1	Pi
	12	8.4	S
	13	8.2	O
	15	8.4	R
	15	8.4	M
	15	8.3	Pi
	18	8.5	Sp
	18	8.4	R
	19	8.3	R
	21	8.4	Pi
	21	8.6	Bu
	23	8.6	M

143227

R Bootis

Mo.	Day	Est.	Obs.
4	4	6.6	M
	6	6.7	M
	8	6.9	Bu
	8	7.1	M
	10	6.9	Ly
	12	7.3	Pi
	13	6.5	O
	15	7.5	M
	15	7.4	R
	17	6.9	Ly
	18	6.1	O
	19	7.4	R
	20	7.3	Ly
	21	7.3	Pi
	21	7.5	Bu
	23	8.0	M

144918

U Bootis

Mo.	Day	Est.	Obs.
4	7	10.5	Sp
	8	10.4	Sp
	8	10.4	Bu
	12	10.4	Sp
	13	11.1	V
	18	10.5	Sp

151731

S Cor. Bor.

Mo.	Day	Est.	Obs.
4	7	7.6	M
	8	7.5	Bu
	11	7.7	Ly
	13	8.0	Ma
	14	7.8	Ly
	15	7.8	Pi
	18	7.9	Sp

S Cor. Bor.

Mo.	Day	Est.	Obs.
4	20	7.9	Ly
	21	8.1	Pi
	21	8.2	Bu
	23	8.3	M

153378

S Urs. Maj.

Mo.	Day	Est.	Obs.
4	11	10.0	Ly
	12	9.9	Sp
	13	10.0	Pi
	17	9.8	Pi
	20	9.7	Ly
	21	9.7	Bu
	30	9.5	Ly

154428

R Cor. Bor.

Mo.	Day	Est.	Obs.
4	2.6	6.0	Bb
	4.6	6.1	Mu
	5.6	6.3	Mu
	5.5	6.2	Bu
	6.6	6.1	Bu
	7.6	6.0	Mu
	7.6	6.1	Bb
	8.6	6.1	Mu
	8.6	6.1	Bu
	9.6	5.8	Bb
	10.6	6.1	Mu
	11.6	6.0	Ly
	12.6	6.3	Mu
	12.6	6.1	Pi
	12.6	5.9	E
	12.7	6.0	S
	13.6	6.2	Mu
	13.5	6.0	O
	13.6	5.9	Ma
	13.7	6.0	S
	14.6	6.4	Mu
	17.6	5.9	Ma
	18.5	6.0	O
	19.7	6.0	Bu
	20.6	5.9	Ly
	20	5.9	Bb
	21.6	6.0	Pi
	21.7	6.0	Bu
	22.7	5.9	Bb
	23.6	6.2	Bb
	25.7	6.2	Bb
	27.6	6.3	Bb
	30.6	6.0	Ly

154539

V Cor. Bor.

Mo.	Day	Est.	Obs.
4	21	8.6	Pi
	23	8.9	M

154615

R Serpentis

Mo.	Day	Est.	Obs.
4	6	7.1	Ly
	11	7.3	Ly
	12	6.8	Pi
	17	7.2	Ly
	20	7.3	Ly
	21	7.1	Pi
	21	7.2	Bu

160118

R Herculis

Mo.	Day	Est.	Obs.
4	12	9.5	Pi
	13	8.9	V

160625

RU Herculis

Mo.	Day	Est.	Obs.
4	13	8.0	V
	23	9.0	M

162119

U Herculis

Mo.	Day	Est.	Obs.
4	11	7.3	Ly
	12	7.6	Sp
	12	7.8	Pi
	16	7.8	M
	20	7.1	Ly
	21	7.2	Pi

162807

SS Herculis

Mo.	Day	Est.	Obs.
4	13	9.2	V

163137

W Herculis

Mo.	Day	Est.	Obs.
4	12	11.3	Sp
	18	11.2	Sp
	21	10.6	Pi

163172

R Urs. Min.

Mo.	Day	Est.	Obs.
3	22.7	10.0	R
4	7.6	9.4	M
	8.7	9.7	R
	11.6	9.6	Ly
	11.7	9.7	R
	14	9.5	Ly
	15.7	9.5	R
	19.7	9.4	R
	21.7	9.2	Bu
	23.6	9.0	M

163266

R Draconis

Mo.	Day	Est.	Obs.
4	7	12.0	M
	7	11.9	Sp
	8	12.0	Sp
	12	11.8	E
	12	12.1	Sp
	18	12.0	Sp

164055

S Draconis

Mo.	Day	Est.	Obs.
4	8	8.7	Bu
	12	8.8	Pi
	14	8.6	M
	17	8.8	Pi
	23	8.4	M

164715

S Herculis

Mo.	Day	Est.	Obs.
4	8	9.4	Bu
	11	9.0	Ly
	13	8.2	Sp
	20	8.8	Ly

171401

Z Ophiuchi

Mo.	Day	Est.	Obs.
4	13	7.7	V

171723

RS Herculis

Mo.	Day	Est.	Obs.
4	8	8.2	Bu
	10	7.9	Ly
	12	8.1	Pi
	13	7.8	V
	17	8.0	Ly
	18	8.1	Sp
	21	8.1	Pi

172809

RU Ophiuchi

Mo.	Day	Est.	Obs.
4	8	9.5	M
	13	9.6	V
	14	10.0	M

175458

T Draconis

Mo.	Day	Est.	Obs.
4	7	11.2	Sp
	8	11.2	Sp
	8	11.0	Bu
	12	11.5	Pi
	12	11.3	Sp
	18	11.3	Sp

180531

T Herculis

Mo.	Day	Est.	Obs.
4	14	9.3	M
	17	9.8	Ly
	21	10.5	Pi
	21	10.4	Bu

180565

W Draconis

Mo.	Day	Est.	Obs.
4	7	11.7	Sp
	8	11.6	Sp
	12	11.6	Pi
	12	11.6	Sp
	14	11.4	M
	18	11.5	Sp

181136

W Lyrae

Mo.	Day	Est.	Obs.
4	14	12.0	M

VARIABLE STAR OBSERVATIONS Mar.-Apr., 1915—Continued.

190108 R Aquilae

Mo.	Day	Est.	Obs.
4	14	11.3	M

190926 X Lyrae

Mo.	Day	Est.	Obs.
4	21	9.2	Pi
	21	9.4	Bu
	30	9.3	Ly

191637 U Lyrae

Mo.	Day	Est.	Obs.
4	21	11.0	Pi

192928 TY Cygni

Mo.	Day	Est.	Obs.
4	24	9.0	M

193449 R Cygni

Mo.	Day	Est.	Obs.
4	4	9.3	M
	4	8.6	Ly
	14	8.5	M
	25	8.4	M

194048 RT Cygni

Mo.	Day	Est.	Obs.
4	4	6.6	M
	14	6.8	M
	25	7.6	M

194348 TU Cygni

Mo.	Day	Est.	Obs.
4	4	9.2	M
	14	9.3	M
	25	9.5	M

194632 χ Cygni

Mo.	Day	Est.	Obs.
4	14	9.8	M

195849 Z Cygni

Mo.	Day	Est.	Obs.
4	4	9.2	Ly
	4	9.2	Ly
	4	9.0	M
	13	9.4	Sp
	14	8.8	M
	25	8.6	M
	30	9.0	Ly

200647 SV Cygni

Mo.	Day	Est.	Obs.
4	4	9.0	Ly
	9	8.6	M
	25	9.1	M

200715a S Aquilae

Mo.	Day	Est.	Obs.
4	14	11.0	M

200916 R Aquilae

Mo.	Day	Est.	Obs.
4	14	8.9	M

200938 RS Cygni

Mo.	Day	Est.	Obs.
4	8.9	8.3	M
	21	7.2	Pi
	25.8	8.3	M

201647 U Cygni

Mo.	Day	Est.	Obs.
4	23	7.3	Ly
	30	10.0	M

202539 RW Cygni

Mo.	Day	Est.	Obs.
4	4.9	8.0	M
	8.9	9.0	R
	14.9	9.2	M
	21	8.2	Pi
	25.8	8.9	M
	28.8	9.2	M
	30	8.4	Ly

202946 SZ Cygni

Mo.	Day	Est.	Obs.
4	25	9.2	M

204016 T Delphini

Mo.	Day	Est.	Obs.
4	23	9.4	M

210868 T Cephei

Mo.	Day	Est.	Obs.
4	21	10.0	Bu
	25	9.8	M

213753 RU Cygni

Mo.	Day	Est.	Obs.
4	8	8.4	M
	25	8.0	M

213843 SS Cygni

Mo.	Day	Est.	Obs.
4	4.8	11.7	Ly
	4.9	12.0	M
	8.8	12.0	M
	14.8	11.8	M
	25.9	11.8	M

213937 RV Cygni

Mo.	Day	Est.	Obs.
4	4.9	8.0	M
	25.9	7.9	M

215715b RW Aquilae

Mo.	Day	Est.	Obs.
4	14.8	9.3	M

230759 V Cassiop.

Mo.	Day	Est.	Obs.
3	22	8.1	R

Monthly Report of the American Association of Variable Star Observers, Apr.-May, 1915.

Mr. Olcott usually writes a few words of interest that are printed with his report. I do not feel that I am capable of giving any advice to the members of this association other than to call to their attention the list of long period variable stars given on page 301 of May POPULAR ASTRONOMY by the director of Harvard College Observatory. These stars are being neglected and should be observed as often as possible.

The following members contributed to this report:—Messrs. Barbour, Bouton, Burbeck, Eaton, Harrell, Lindsley, Mach, McAteer, Mundt, Olcott, Pickering, Richter, Spinney, Vrooman, Miss Swartz and MissYoung.

ALLAN B. BURBECK.

No. Abington, Mass. May 9, 1915.

Observing the New Moon.—Noting that the New Moon occurred at a very favorable time for observing an early appearance in the west, I sought a suitable point for scanning the western horizon and after a few moments searching found the moon by means of a pair of field glasses. I then glimpsed it twice with the naked eye at $7^h\ 44^m$ p. m., May 14, just $21^h\ 13^m$ after conjunction with the sun.

I do not know what the record is but imagine that $21^h\ 13^m$ could not, at least in this latitude, be reduced to any great extent. I should be glad to hear of any earlier observations.

WILFRID GRIFFIN.

Pittsfield, Mass.
102 W. Housatonic St. May 17, 1915.

GENERAL NOTES.

Professor S. A. Mitchell, director of the Leander McCormick Observatory, has again been awarded the Ernest Kempton Adams Fellowship by Columbia University. The money for this is being devoted to researches on stellar parallax by photography. During this year Professor Mitchell and his assistants have taken 1275 photographs on 160 different regions in pursuance of the parallax work.

The Leander McCormick Observatory at the recent meeting of the National Academy of Science was awarded a grant from the J. Lawrence Smith fund to further meteor investigations. Dr. Charles P. Olivier, who is a recognized authority on this work, has an article in this number of POPULAR ASTRONOMY which will be of interest to all meteor observers.

Summer Courses in Orbit Theory at the University of California.—A rare opportunity for the study of methods of computing orbits will be given during the coming summer session at the University of California. Professor A. O. Leuschner, director of the Students' Observatory and Dean of the Graduate School, will offer two courses; one on Orbit Theory, covering the Laplacian and other methods of deriving orbits of comets, planets and satellites; the other a seminar on orbit theory, with numerical derivation of orbits. The first course is open to students who are familiar with differential and integral calculus and with the fundamental principles of general and practical astronomy. The second course is open to those who are taking or have taken a course in orbit theory.

The classes will meet for organization, June 22, 1915.

Publication of the Gazette Astronomique Resumed.—The publication of the *Gazette Astronomique*, edited by the Astronomical Society of Antwerp, was interrupted by the war and temporarily discontinued after August 31, 1914. After the fall of Antwerp on October 9 a large number of the members of the society left the city. Later the four members of the editorial committee met in England and, through the initiative of Mrs. Fiammetta Wilson and the generous encouragment and coöperation of British astronomers, found it possible to resume the publication of the journal in England. Number 82 has just been received. Much of the matter is printed in English for the convenience of the English readers. Because of the uncertainty of issues at fixed dates, the subscription price has been fixed as five shillings for a series of twelve numbers.

In the current number is given a long description of present conditions at the Royal Observatory of Belgium at Uccle. It is now in the hands of the Germans, who are using it as a meteorological station for the airship service. The Belgian astronomers are permitted to continue their work, although the director of the observatory, M. George Lecointe, is an officer in the Belgian army, and is at present interned in Holland.

It is proposed for the coming numbers to publish a paper on "War, Science and Scientists," with special reference to astronomy, and later a paper on the work of J. C. Houzeau, the Belgian astronomer who spent a good deal of his life in America and played a prominent part in American politics.

London Skies in War Time.—One of the many "by products" of the great war is the opportunities which have of late been enjoyed by astronomers living in and near London to observe the heavens with comparatively little interference due to city lights. At a recent meeting of the British Astronomical Association attention was called to the fact that the zodiacal light had become an easily observed feature of London skies, whereas before the days of Zeppelin raids it was practically invisible to Londoners. (*Scientific American*, May 22, 1915.)

Saturn Seen Oval with the Naked Eye.—A correspondent of Mr. E. Walter Maunder, the English astronomer, claims to have frequently seen Saturn distinctly oval with the naked eye during the last winter. The position of the rings has been favorable for such an observation during the last three or four years, and it is within the power of strong opera glasses. A naked-eye observation is somewhat questionable. An elongation of the bright image due to astigmatism might explain it. It would be interesting to hear from other keen-eyed observers on this subject. (*Scientific American*, May 22, 1915.)

The Heavens on a Parasol.—The novel and rather practical idea of using an umbrella or parasol in place of a celestial globe is suggested in an article in the *Scientific American* for May 22, 1915. The constellations may be painted either on the outside or the inside of the umbrella, the steel ribs corresponding to celestial meridians or hour circles. The umbrella may be set in a table, which will represent the horizon, and clock-work attached to the handle of the umbrella may be used to give the rotation necessary to illustrate the daily turning of the heavens.

The Agassiz Association Observatory.—The Agassiz Association, of Arcadia, Sound Beach, Conn., of which Mr. Edward F. Bigelow, Editor of *The Guide to Nature*, is president, is making an effort to establish an astronomical observatory, with a six-inch telescope for popular observation, hoping that it will lead to the establishing of a larger observatory. They ask the aid and encouragment of those interested in the promotion of astronomy.

According to the circular issued, "Sound Beach is in the eastern part of Greenwich, the richest town in the United States. It is near Stamford, a prosperous, rapidly growing city. It is thirty-five miles from New York City, in an ideal location for a large observatory. There is none better in this part of the United States. We hope to induce one or more of the multimillionaires in this town to establish a well-equipped observatory. This can be done if their interest can be aroused and public approval be shown especially by astronomers."

POPULAR ASTRONOMY is always ready to approve and to encourage steps which will lead to wider interest in astronomy and we believe thoroughly in the usefulness of the observatory which may be frequently open to the public at regular intervals. Everyone ought to know something of the story of the universe and nothing gives more of a stimulus to the study than an occasional look through a good telescope at some of the wonders of the sky.

A New Greenwich Astrographic Catalog.—Volume 3 of the Greenwich section of the Astrographic catalog contains in its part A a catalog of 2212 stars within 3° of the North Pole. This part gives the positions of the stars in rectangular coördinates, since right ascensions and declinations would be inconvenient in this part of the sky. The positions were obtained from measurements on the Astrographic plates. The catalog plates were given short exposures, usually six minutes, and show images of stars as faint as magnitude 14 on the scale of the Harvard Polar Sequence. The area covered is 28.3 square degrees and therefore the density of the stars is 78 to a square degree. The average star is found on three plates. About one quarter of the stars were measured on one plate only, while a few of them were found on five plates. The rectangular coördinates are referred to a plane tangent to the heavens at the center of the plate.

The focal length of the telescope is about 330 centimeters and the plate covers an area 2° square. The star positions were measured at a maximum distance of 65′ from the center of the plate. It is of interest to compare the probable error of a measured position of these Astrographic plates, with the corresponding errors in the meridian circle catalogs of the Gesellschaft and also with the errors found by Schlesinger on his plates, taken with the camera of focal length of 163 centimetres, therefore just about half the focal length of the Astrographical telescope. The probable error of one Greenwich observation is given as

$$\pm\ 0''.228.$$

The corresponding quantity of Schlesinger's plates is

$$\pm\ 0''.174$$

The probable error of the meridian circle position is given by Schlesinger as somewhat greater than $\pm\ 0''.50$.

It will be seen from the above comparison that the star places from the photographs are two or three times as precise as the positions from the meridian circles. The reality of this advantage would seem to be confirmed by comparison made with the Vassar catalog of polar stars obtained by Miss Furness from measurements of plates taken at Helsingfors. This comparison showed a systematic difference in the scale of the plates of about one part in twenty thousand and a difference in origin of 0.″4. After allowing for this systematic difference, the agreement between the two catalogs was within 0″.3. The above differences are largely due to the standard stars, which were quite different for the two catalogs.

This Greenwich catalog gives the photographic magnitudes based on the stars of the Harvard North Polar Sequence. The magnitudes were obtained from the diameters of the star images, which were estimated by comparison with the divisions of the glass scale used in the measuring microscope. This scale division was 3″ of arc, and the diameters were estimated in tenths of a scale division. The recorded estimates range from 4 to 50. The formula used for changing diameters to magnitudes is due to Christie, the former Astronomer Royal, and is

$$M = a - b\sqrt{D}$$

Comparison of the various plates gives ± 0.20 as a probable error of a single magnitude determination, corresponding to about ± 0.10 as the probable error of a catalog magnitude. It is interesting to compare Seares' results on the Polar Sequence, lately published, which give the average deviation of the measured magnitude as $\pm\ 0.125$. This would correspond to a probable error of 0.02 or 0.03 of a magnitude for the catalog values. The corresponding probable error in the Yerkes Actinometry was 0.024.

The main part of the volume contains the Greenwich catalog from declination + 90° to + 64°. This contains 16,780 stars of magnitude 9.0 or brighter, and is arranged in zones like the Bonn Durchmusterung. It contains, beside the photographic magnitudes, the right ascension and declinations for the year 1900, with the precession and secular variation, as well as comparisons with the catalogs of Carrington and the Gesellschaft. The magnitudes in this catalog were found from a special series of plates containing duplicate exposures on the field and the North Polar Sequence. The diameters of the stars were measured and reduced in the same manner as described in Part A. The positions are determined with a greater precision than meridian circle places and are given for an epoch (1900) 25 years later than Gesellschaft catalogs. "It is proposed to use the material of this work for the determination of proper motions, and to utilize the photometry plates for the investigation of the magnitudes of the fainter stars given in Volumes I and II."

J. A. PARKHURST.

Yerkes Observatory, May 1915.

The Riddle of Mars.—The Riddle of Mars is the name of a small book by C. E. Housden, published last year by Longmans Green and Co., New York. The author offers as an explanation of the changes which are noticed in the appearance of the planet an elaborate system of irrigation. The author assumes that at any time considerably more than half of the surface of the planet is at a temperature above freezing. Only in the neighborhood of one of the poles is the temperature below freezing. At the other pole the snow is melting and setting free large volumes of water. The surface being very nearly level the water collects in the lower regions near the poles. From these instead of being left to evaporate it is pumped through rising mains to collecting reservoirs. From these either by gravity or by further pumping stations it is distributed to service reservoirs, and from there to the regions to be irrigated possibly in the form of showers. He supposes these large and numerous pipes which would be sufficient to convey the large quantities of water to be placed side by side, and that it is this arrangement of straight lines which is seen and interpreted as "canals". Possibly the same conduit system conveys the water from the southern hemisphere to the northern in one season and from the northern to the southern in the other season, thus sustaining the growing vegetation in the hemisphere which would naturally be in winter, or at least barren from lack of moisture. To carry out this pumping of the water through the pipes would require about 4000 times as much power as is now under development at the Niagara Falls. This therefore is within the range of possibility. It is possible that much of the water is obtained from wells otherwise the polar cap would diminish in size from year to year because of the loss by the soaking into the ground of the water sprinkled upon the cultivated sections. A small system of this kind is in operation in Coolgardie, Australia, by which water is raised 1290 feet in 351½ miles at the rate of 5,600,000 gallons per day

Granting conditions to exist on Mars as set forth in this book. one at the same time is led to admit the inhabitation of Mars, and that the people there, possible from necessity, have devised this enormous water system, which however, conceivably might be developed on the earth also.